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THESIS

THE AMMUNITION SUPPLY CHAIN AND INTERMODALISM: FROM DEPOT TO FOXHOLE

by

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In order to understand how ammunition can be transported effectively and efficiently, the supply chain must be examined to identify choke points, limitations and short-falls that occur during the ammunition movements from the depot to the "foxhole."

This thesis examines the issues affecting the ammunition supply chain within the DoD and the Defense Transportation System. Analysis and recommendations are provided to improve the transportation of ammunition through this system.

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THE AMMUNITION SUPPLY CHAIN AND INTERMODALISM: FROM DEPOT TO FOXHOLE

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ABSTRACT

The Department of Defense (DoD) has started a modernization effort to support the movement of ammunition and general cargo for contingency operations. This modernization effort includes the procurement of new intermodal containers, container handling equipment, port upgrades and agreements with commercial industry.

In order to understand how ammunition can be transported effectively and efficiently, the supply chain must be examined to identify choke points, limitations and short-falls that occur during the ammunition movements from the depot to the "foxhole."

This thesis examines the issues affecting the ammunition supply chain within the DoD and the Defense Transportation System. Analysis and recommendations are provided to improve the transportation of ammunition through this system.

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I. INTRODUCTION

The movement of ammunition is critical in supporting the warfighter during war. The methods and ability to provide the right type of ammunition at the right place and at the right time requires an enormous infrastructure. The ammunition chain starts at the depot and ends when the user receives the ammunition which is usually in the "foxhole". The ammunition supply chain is only a small part of the total distribution chain that gets supplies to the warfighter.

One of the new operational concepts under Joint Vision 2010 is "Focused Logistics" which relies on the armed force's ability "to project power with the most capable forces, at the decisive time and time." [Ref. 6:p. 44] An effective and efficient supply chain will enable Joint Vision 2010 to succeed. Improving the supply chain can contribute to a smooth flow of support to joint forces during peacetime and war. The ammunition supply chain relies on the Nation's ability to respond with the right amount of support at the right time.

Containerization optimizes the movement of cargo by combining small loads into a unit inside a standardized container. Using containers minimizes handling damage and

supports the ease of movement of the cargo. Containerization incorporates supply, transportation, packaging, storage and security together with visibility of containers and it's contents into a distribution system from the source to the user. [Ref. 19] Containerization is a major part of the overall distribution supply chain, and ammunition is primarily moved in containers. Though an analysis of the ammunition supply chain, we can identify the factors that impede the process flow of the chain and offer recommendations for improvement.

A. DISCUSSION

Operation Desert Shield/Desert Storm was the first major U.S. Military conflict since the commercial container revolution. While containers were used in this effort, their full potential was not realized, and containers played a small part in the movement of ammunition. The Mobility Requirements Study (MRS) of 1992 and the subsequent MRS Bottom-up Review Update (MRSBURU) of 1995 conducted by the Joint Chiefs of Staff identified the benefits of containerization to support military contingencies. [Ref. 14, 16] The reviews recommended changes that would make ammunition distribution more efficient. There are still facility deficiencies and imbalances within the depot-to-theater container delivery systems, including in-transit

visibility, infrastructure, and Container Handling Equipment (CHE).

DoD has started a modernization effort to support the movement of ammunition and general cargo for contingency operations. This modernization effort includes the procurement of new roll-on/roll-off ships, port upgrades, agreements with commercial industry, development of new equipment, and modifications to existing equipment.

In order to understand how ammunition can be moved effectively and efficiently, the supply chain must be examined to identify choke points, limitations, and shortfalls that occur during ammunition movements from the depot to the user. A study of the ammunition supply chain with an examination of ammunition exercises can determine the capability and productivity of the chain.

B. AREA OF RESEARCH

This thesis will identify and evaluate containerized conventional ammunition operations within the Department of Defense (DoD) for ground and aviation forces. The objective is to lay out the DoD ammunition supply chain and analyze the effectiveness and efficiency of the chain. Naval ammunition will not be addressed since resupply is primarily conducted using organic Naval assets. In general, each service is responsible for providing logistical support to

their own services except as provided by common or cross level logistics. Common or cross level logistics is a function performed by one military service such as the Army supporting the Air Force. The Army ammunition supply chain model is used throughout this thesis because the Army is usually the dominant user of ammunition. The Army also has the majority of assets (ammunition units and transportation assets) to provide support to other services. Most services receive ammunition from Army storage areas in a theater of operations.

C. SCOPE OF THE THESIS

This thesis will primarily look at the total ammunition flow process, how containerization differs from breakbulk operations, and how modernization efforts have affected the flow. It will examine commercial business integration in the ammunition supply chain, as well as the outcomes of the TURBO Containerized Ammunition Distribution System (CADS) exercises. The intention of this thesis is to examine the total ammunition supply chain and provide recommendations to improve the flow process in the future.

D. RESEARCH QUESTIONS

The primary question addressed by this thesis is:

- What is the current process of the ammunition supply chain in the DoD, and how can this be improved?

The secondary questions addressed by this thesis are:

1. What are the steps for requisitioning ammunition?
2. How is ammunition distributed from depots to the end user?
3. What are the choke points and limiting factors in the ammunition supply chain?
4. Can the current process be further streamlined?
5. How is commercial transportation used in the ammunition supply chain?
6. What are the advantages and disadvantages of including commercial transportation in the chain?
7. What is the impact of the Voluntary Intermodal Sealift Agreement (VISA) on the ammunition supply chain?
8. What are the different types of ammunition containers and related equipment in the DoD inventory?
9. What are the advantages and disadvantages to containerization versus non-containerization?
10. How has DoD's modernization efforts impacted the ammunition supply chain?
11. What systems are used to manage ammunition to ensure In-transit Visibility (ITV) and Total Asset Visibility (TAV)?
12. What are the current projects/exercises used to evaluate the ammunition supply chain?
13. What are the lessons learned from the CADS exercises sponsored by USTRANSCOM (United States Transportation Command) TURBO CADS exercises, and how can these lessons be applied to improve the ammunition supply chain?

E. ORGANIZATION

This thesis is organized into seven chapters. Chapter I serves as an introduction to the research issues.

Chapter II provides background information on the ammunition supply chain. It describes how the chain flows across the three levels of war and discusses the differences between the wholesale and retail level of ammunition support.

Chapter III discusses containerized ammunition equipment. The different types of containers and container handling equipment is addressed, as well as the different types of container ships and ports.

Chapter IV examines the flow process of the ammunition supply chain. It covers management systems, flow regulation measures, the flow process, and containerized transportation capabilities. This chapter also identifies choke points in the process flow, as well as the difference between wartime and peacetime flow of ammunition. The impact of the Voluntary Intermodal Sealift Agreement is addressed in relation to its impact on the supply chain.

Chapter V looks at the lessons learned from past TURBO CADS exercises and the impact on the supply chain. This chapter discusses how the lessons learned can be applied to improve the ammunition supply chain.

Chapter VI will present an analysis of the ammunition supply chain. The factors that impede the flow process such

as choke points and limitations are analyzed. Additionally, future trends in the ammunition supply chain are discussed.

Chapter VII provides a concise overview of our conclusions concerning the current state of containerized ammunition, as well as our recommendations for dealing with current and anticipated problems in the ammunition supply chain.

II. BACKGROUND OF THE AMMUNITION SUPPLY CHAIN

A soldier can survive forever without mail; for thirty days without food; for three days without water; for three minutes without air; and not one second without ammunition.

Author Unknown

A. INTRODUCTION

Logistics is considered "the foundation of combat power," and integrates the strategic, operational, and tactical sustainment efforts in operations. [Ref. 5:p. 1] The ammunition supply chain is only one facet of the overall logistics supply chain. The ammunition chain is a logistics pipeline that starts at the factory or depot and ends at the foxhole or the end-user of the product. It stretches across the three levels of war: strategic, operational, and tactical. (See Figure 1) There are significant operations at each level in the chain that contribute to providing support to the warfighter in a timely, effective, and efficient manner. [Ref. 6] This chapter looks at the operational functions of the ammunition supply chain that take place at each level of war.

Ammunition is defined as "ammunition of all types, bombs, explosives, mines, fuses, detonators, pyrotechnics,

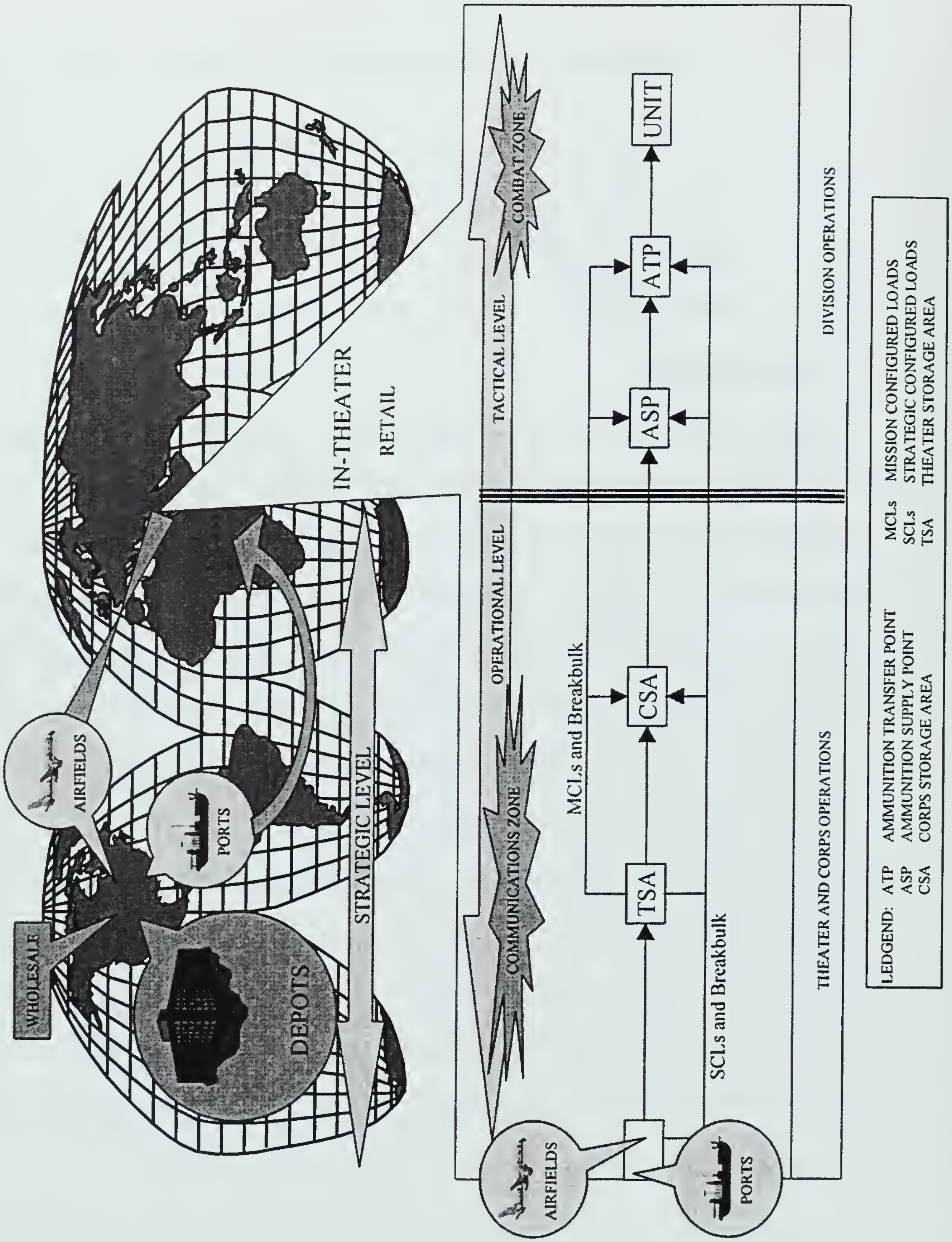


Figure 1. Ammunition Supply Chain

missiles, rockets, propellants, and other associated items." [Ref. 8:p. A-6] The ammunition supply chain is designed to provide responsive ammunition support to deployed forces anywhere in the world. The unique characteristics of ammunition can complicate the supply chain. Munition characteristics include size, weight, hazardous nature, storage and special handling requirements, accountability, and security issues. [Ref. 8:p. A-6] The ammunition system is divided into two distinct yet mutually supportive parts: the wholesale ammunition distribution system and the retail ammunition distribution system. [Ref. 7:p. 1-5]

The wholesale distribution system is associated with the strategic level of operations located within the United States. The system consists of resource managers located at the Industrial Operations Command (IOC), each service, ammunition plants, depots, and transportation control agencies such as the U.S. Transportation Command (USTRANSCOM). The wholesale system is the support base for all deployed forces. Ammunition is produced based on projected ammunition resupply demand rates as determined during planning for operations, or the actual ammunition forecast for the theater of operation.

The retail ammunition distribution system is associated with the operational and tactical levels of war. This

system includes all supply and transportation activities necessary to provide ammunition to each service within a theater of operations. The IOC inventory control point (ICP) item managers run the retail level for the Army. Each of the other services has retail ICP item managers for managing retail stock. Each service maintains retail stocks for peacetime use and initial ammunition loads for wartime.

B. STRATEGIC LEVEL

The beginning of the ammunition supply chain starts at the strategic level of war, or the wholesale level. The strategic level covers planning and operational requirements, the manufacturing, the storage of ammunition in depots, and transportation inside and to locations outside the United States.

The amount of ammunition needed to support the requirements of the armed forces for possible contingencies is determined by strategic planners such as unified combatant commanders or Commanders In Chief (CINCs), and service component commanders. The requirements are based on the National Security Strategy, the National Military Strategy, the expected military missions required to achieve strategic end states, and theater strategies and campaign plans. Commanders consider the "availability of stocks,

storage locations, deployability into various theaters, and the responsiveness of the production base to meet shortfalls" when determining the requirements for ammunition. [Ref. 8:p. A-1]

The Army Material Command (AMC) is responsible for acquiring the ammunition for all the U.S. military services. This is done by the Industrial Operations Command (IOC), a subordinate command of AMC, located in Rock Island, Illinois.

The Single Manager for Convention Ammunition (SMCA) center performs management of convention ammunition at the strategic level. Some aviation munitions and missiles are considered non-conventional and managed by the Aviation and Missile Command. The SMCA center is responsible for life cycle management of ammunition, from coordinating the procurement of ammunition for new weapon systems to running depots and disposal. [Ref. 13] The center receives input from the CINCs and service component commanders to determine the distribution and procurement of ammunition. The SMCA center is the National Inventory Control Point (NICP) for munitions with managers responsible for controlling several types of munitions. Each munition is tracked, issued, and stored by a Department of Defense Identification Code or

DODIC. Table 1 shows the total amount of DODICs managed as of January 1998 by the IOC.

User	Army	Navy	Air Force	Marine
Items	3770	3544	1275	888

Table 1. Service Items Managed by the SMCA Center [Ref.13]

There are a number of storage facilities at the strategic level. Ammunition is stored at several depots throughout the United States, in limited locations overseas, and on prepositioned ships. Since the closing of several forward bases overseas, maritime prepositioning of ammunition provides flexible support to forward presence units until ammunition is shipped from the United States. [Ref. 8] In the Continental United States (CONUS), ammunition is stored in depots using a tiering concept which is discussed below. Strategic planners use several factors when considering the level of support required for a given operation. Decisions of how much ammunition to procure, store, ship, and dispose are based on current and planned operations. Ammunition can be shipped into theaters using a configured load concept that allows large volumes of ammunition to move quickly from the depot or theater storage area to the user. Most ammunition is shipped into theaters

in unit loads which are packaged into containers to maximize the utilization of the container.

1. Ammunition Tiering

After the end of the Cold War, the need for large stockpiles of conventional munitions decreased. The Mobility Requirements Study of 1993 conducted by the Joint Chiefs of Staff recommended a smaller, safer, and better quality stockpile of ammunition with a reduced workforce using fewer storage installations. [Ref. 18] Since the majority of ammunition consumption during peacetime is for training, a plan was developed to divide CONUS into an eastern, central, and western region for supplying ammunition. Except for the eastern region, each region received one ammunition facility to reduce the cost of transporting training ammunition during peacetime. The eastern region received two facilities because of the larger density of military bases located in that region in comparison to other regions. The facilities were broken down into different types of "Tiers" based on their function. A Tier I facility stores the first 30 days of war reserve ammunition and ammunition for training. The war reserve ammunition is shipped from Tier I facilities first during a war. Tier II facilities store war reserve ammunition to be used after the first 30 days, and Tier III

facilities store excess ammunition. Two of the Tier III facilities, Seneca and Savanna, are scheduled for closure under the Base Realignment and Closure (BRAC) decisions of 1995. Table 2 lists the name and location of each depot by Tier.

TIER I	LOCATION
Eastern	Blue Grass Army Depot, Kentucky
	Crane Army Ammunition Activity, Indiana
Central	McAlester Army Ammunition Plant, Oklahoma
Western	Tooele Army Depot, Utah

TIER II	LOCATION
Eastern	Anniston Army Depot, Alabama
	Letterkenny Army Depot, Pennsylvania
Central	Red River Army Depot, Texas
Western	Hawthorne Army Depot, Nevada

TIER III	LOCATION
Eastern	Seneca Army Depot, New York
Central	Savanna Army Depot, Illinois
Western	Sierra Army Depot, California

Table 2. Ammunition Depot Tiers [Ref. 11]

2. Strategic Considerations

The ammunition supply chain must be capable of supporting each service, joint forces, and a variety of multinational forces. During the planning of operations and

determination of requirements, several factors are used to determine the overall ammunition support strategy. The development of new technologies such as laser guided bombs, artillery projectiles, and the future development of high-lethality technologies will reduce the volume of ammunition needed for future conflicts. "It is unlikely that future conflicts will require the massive volumes of stocks needed to support the European AirLand force of the 1980's." [Ref. 8:p. A-2] Although smaller amounts of ammunition may be needed in the future, strategic planners must also consider the operational and tactical level factors in their plans to ensure all contingencies in the supply chain are covered. The following are some factors considered by strategic planners:

- Total requirements
- Stockpile management including acquisition, long term storage, and strategic projection (distribution) into theater.
- Recovery
- Retrograde movement
- Disposal of ammunition stocks [Ref. 7:p. 2-2]

Some considerations at the operational and tactical level are capabilities of the transportation system, understanding the CINC's requirements and priorities, and

the needs of joint and multinational forces. Prior planning for operations will determine what kind of support is needed to move ammunition to the user.

3. Configured Loads

Configured loads were designed during the cold war to provide high usage ammunition quickly within a theater of operations. Configured loads were originally designed for artillery units who are traditionally the largest volume users of ammunition. Configured Loads are pre-planned packages of ammunition designed to fit on a semi-trailer or a Palletized Load System (PLS) flatrack. The packaged ammunition is transported as a single unit and supports a particular type of combat unit or weapon system. Planning for configured loads happens in peacetime to enhance wartime resupply coordination to the tactical level. [Ref. 7:p. 2-8] An example of a configured load would be artillery rounds that are grouped together with the primer and gunpowder to form a single shipment load to an artillery unit.

When the configured load is packaged at depots in the United States, it is considered strategic or a Strategic Configured Load (SCL). An SCL is designed to fit inside a container, but it can also be moved in breakbulk form. Containerization keeps an SCL together as a single unit, which makes it more efficient to transport.

When a configured load is packaged at the operational or tactical level, it's considered a Mission Configured Load (MCL). [Ref. 35] The Cold War term for MCL is a Combat Configured Load (CCL) a term still used in older publications. For both types of loads, the ammunition end user is at the operational and tactical level.

There are currently forty-nine designated configured loads to support units that may deploy to a theater of operations. [Ref. 3] New equipment is being developed to enhance the supply chain using SCL and MCL concepts. The new equipment, the types of equipment, and containers used to transport and handle ammunition will be discussed in detail in Chapter III.

C. OPERATIONAL LEVEL

The operational level starts when ammunition leaves the United States and enters the theater of operations at ports and airfields, and ends at the tactical area. (Figure 1) The operational level is the link between the strategic and tactical level of war and is sometimes referred to as the Communications Zone. The operational level is responsible for establishing the theater level reception, management, and distribution of ammunition. Most ammunition arrives in the theater of operations in containers.

In the past, the maritime transportation industry primarily utilized breakbulk cargo ships for transporting dry goods, and DoD relied on commercial breakbulk ships for military shipments, including ammunition. In the past twenty-five years, however, there has been a revolution in the transportation industry, leaving behind the traditional breakbulk methods and shifting to intermodal container transportation. The commercial maritime industry has developed internationally recognized standard equipment that can operate intermodally using ships, railroad, and trucks to efficiently transport container around the world.

Containerization is an effective part of the intermodal system at the strategic and operational levels, but requires a large amount of container handling equipment to unload the containers from ships or barges. The other way to move ammunition is by the breakbulk method. Moving ammunition by breakbulk is an inefficient way to move large volumes of ammunition when compared to containerization. Breakbulk involves moving individual pallets of munitions and is therefore quite labor intensive. On the other hand, the equipment required to move and store many pallets at one time, as a single unit through containerization, is quite capital intensive.

Moving ammunition in breakbulk is "primarily used at ports which, either because of low cargo volume or local economic factors, lack the modern facilities" to off-load container. [Ref. 18:p. IV-1] Self-sustaining container ships and Logistics Over The Shore (LOTS) operations reduce the required to utilize breakbulk method because of a lack of modern port facilities. The Defense Transportation System (DTS) relies on commercial industry and technology for new methods of shipping cargo. Breakbulk shipping operations is no longer economically viable in commercial shipping operations since the development and wide spread use of the containers and container ships. [Ref. 18:p. IV-2]

Moving ammunition in containers is the preferred method because of the efficiencies in handling and storage that containers provide. Containerizing improves the delivery times of resupply by reducing handling, ship loading, and discharge time. [Ref. 10:p. 3-3]

Normally, each service is responsible for support of its own forces except when that support is provided for by agreements with other services. When deployed for major operations, all the services become interdependent, and the CINC may designate a particular service, usually the dominant user, to provide ammunition support for the entire theater. [Ref. 8] The Army ammunition supply chain model

at the operational and tactical level is used in this thesis because the Army is usually the dominant user of ammunition. The Army also has the majority of assets (ammunition units and transportation assets) to provide any needed support to other services.

Ammunition is received at ports and airfields, and then moved to storage areas. The storage areas are Theater Storage Areas (TSAs) and/or Corps Storage Areas (CSAs). General support (GS) ammunition companies from the Army provide conventional ammunition support to the theater by establishing and running TSAs and CSAs. Once ammunition is transported to an individual service, they are responsible for storage.

Management of ammunition at the operational level is conducted by Material Management Centers (MMCs) located at the theater and corps level. The Theater Army Material Management Center (TAMMC) "serves as the primary interface between the theater and the sustaining base." [Ref. 10:p. 2-15] Ammunition received from the strategic level is distributed to TSAs and CSAs by the TAMMC. The Corps Material Management Center (CMMC) coordinates with the TAMMC and provides the management link between the tactical and operational level. [Ref. 8] (See Figure 2)

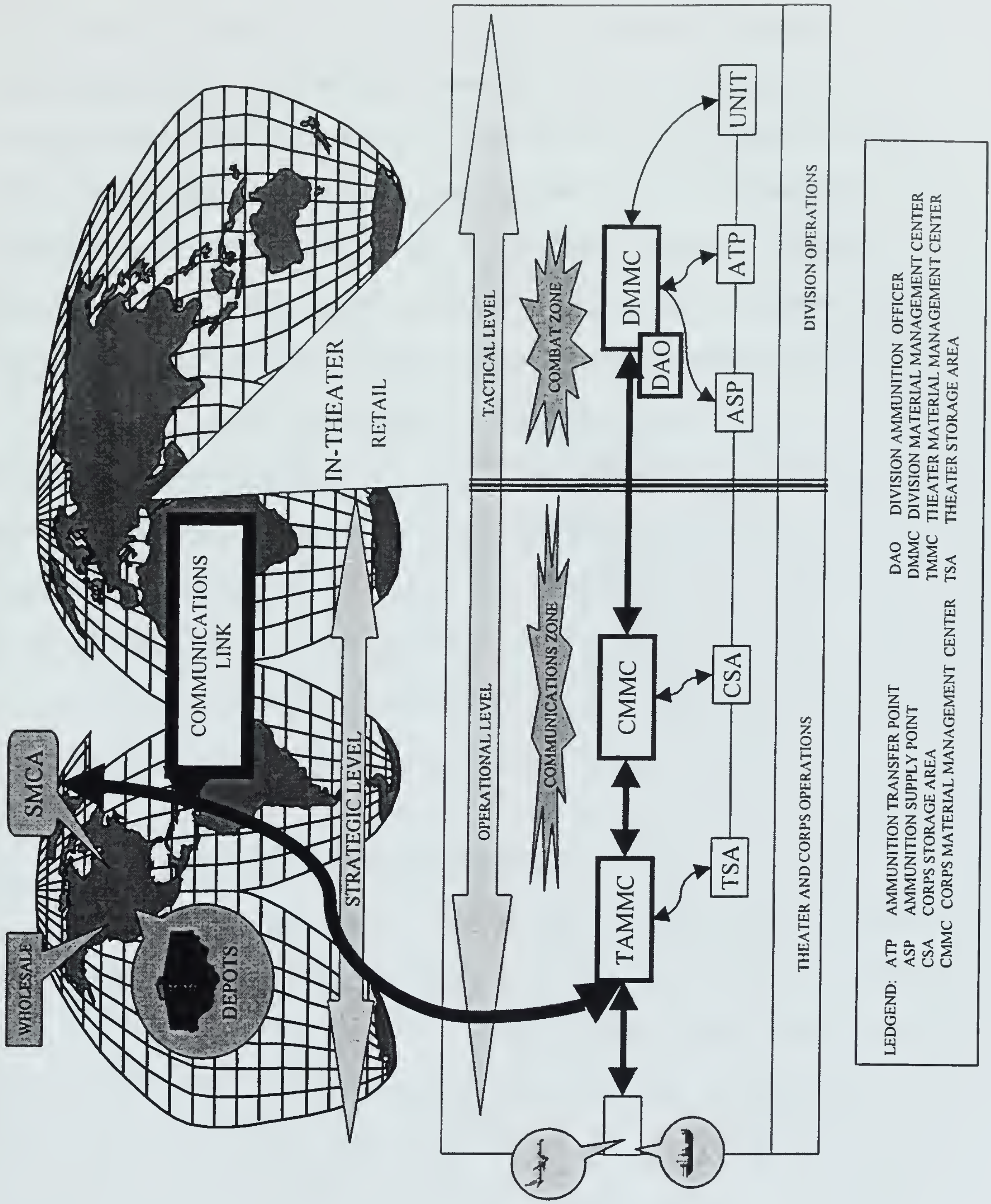


Figure 2. Ammunition Management

D. TACTICAL LEVEL

The tactical level is where the ammunition supply chain ends. Ammunition planning is conducted at this level to ensure ammunition is available to the maneuver commander who is usually in charge of the combat forces. Storage areas in the tactical level are called ammunition supply points (ASPs) and ammunition transfer points (ATPs). (See Figures 1 and 2) Tactical storage areas are used for temporary storage before moving ammunition forward on the battlefield. Direct support (DS) ammunition companies of the Army provide the support to establish and run ASPs and ATPs. [Ref. 7: p. 1-5] Each DS ammunition company has the capability to establish and operate three ASPs and one ATP.

The ASP provides ammunition to ATPs, and provides area support to non-divisional units in a Division area of operations. ATPs are established and operated by forward support units of each Division. ATPs provide ammunition to combat units. Ammunition in an ATP is stored on PLS flatracks or semi-trailers.

Providing the required quantity and type of ammunition to the combat user at the right time and place requires a responsive and flexible supply chain. The Maneuver Oriented Ammunition Delivery System (MOADS) uses Mission Configured Loads (MCL) to deliver ammunition to most combat units.

MOADS delivers ammunition to high volume users such as field artillery, armor, infantry, aviation, combat engineers, and air defense units. [Ref. 8] The Palletized Loading System (PLS) is primarily used to provide ammunition to units using the MOADS concept, and its versatility in the ammunition supply is important. [Ref. 12] The ammunition supply chain ends at the ATP or when a unit receives the ammunition.

Management of ammunition at the tactical level is done by a Division Ammunition Officer (DAO) who is responsible for coordinating ammunition efforts in the tactical level or combat zone with the ASP, ATP, and units. The DAO interfaces with the CMMC and TAMMC on ammunition issues, and is located in the Division Material Management Center (DMMC). [Ref. 7:p. 2-12] (See Figure 2)

E. AMMUNITION FOR OTHER SERVICES

When ammunition enters a theater of operations, it is designated for different services by the DoD Identification Code (DODIC) for each type of ammunition. Most ammunition designated for services other than the Army is shipped to that service directly when it arrives in the theater, or it is stored at the TSA. This is dependent on the other service's organic storage capabilities and support

agreements. Theater transportation assets are used to deliver ammunition to Air Force and Marine Corps units.

The U.S. Marine Corps (USMC) maintains an initial 30-day supply of ammunition with the Marine Expeditionary Unit (MEU). This ammunition is used until the supply chain is established from CONUS. USMC doctrine emphasizes the use of organic transportation assets to move ammunition, and places less emphasis on a structured distribution system. If ammunition designated for the USMC arrives in theater, it will most likely be delivered to the Forward Service Support Group (FSSG) who then handles distribution for the Marine Corps. [Ref. 9]

Similarly, Air Force units will receive ammunition from the ports, airfields, or the TSA. Initial ammunition arrives via preposition ships until the supply chain is established. The Air Force uses organic assets to move ammunition once it is delivered to an air base.

The IOC stores Naval munitions at the wholesale level and transports it to Naval magazines for retail use. The Navy resupplies ammunition to its ship at sea using specialized replenishment ships. Naval ammunition is not discussed in the remainder of this thesis because it does not utilize or rely on the Outside Continental United States

(OCONUS) portion of the supply chain as much as the other services. Also, naval ammunition operations, as presently configured, are not easily adaptable to standard intermodal containerization for the complete movement from depot to supply ship, much less to the warship (combatant ship).

F. CONCLUSION

The ammunition supply chain involves many parts that can extend for thousands of miles across the three levels of war. The characteristics of munitions require a large infrastructure to transport it from the wholesale level to the retail level. Controlling and managing ammunition requires extensive coordination, planning and communication. The strategic or wholesale level produces, stores and issues ammunition to the retail level. The retail level is associated with the operational or tactical level of war. Once ammunition is received in the theater of operations, it is distributed to storage areas or to the user. Sometimes ammunition is received in strategic configured loads or reconfigured into mission loads to improve the flow process to the using unit or storage area.

The next chapter discusses containerized ammunition equipment. It examines the specific types of equipment,

ships, and containers used to transport ammunition to the warfighter.

III. CONTAINERIZED AMMUNITION EQIUPMENT

A. INTRODUCTION

Specialized equipment is a prerequisite for the effective use of intermodal transportation. The decision to transport ammunition intermodally is based on a number of factors. DoD Directive 4500.37, *Management of the DoD Intermodal Container System,* states that containerization is the preferred method of ammunition shipment primarily based on efficiency. However, a number of obstacles prevent the complete shift to intermodal ammunition transportation. These obstacles lie in the unique elements required to utilize intermodal transition.

This chapter presents the different container types and container handling equipment (CHE) used in transportation of munitions intermodally. Intermodal vessels used in ammunition transportation are also discussed.

B. AMMUNITION CONTAINERS AND CONTAINER HANDLING EQUIPMENT

The Department of Defense (DoD) uses several types of containers and handling equipment to support the deployment and sustainment of the armed forces. The following are used specifically in the transportation of ammunition.

1. MILVAN - Ammunition Restraint

The MILVAN is a specially designed, end-opening container developed to carry between 31,560 lbs. and 39,800 lbs. of ammunition. The MILVAN has an internal restraint system that is made up of rails permanently installed along the sides of the container and 25 adjustable crossbars designed to keep the ammunition from moving inside the container. Fork lift pockets are placed along the bottom sides for easy CHE access. Most MILVANs are 8 feet wide, 8 feet high and 10 or 20 feet long; however, some have been procured that are 8.5 feet high. Both of these MILVAN sizes also meet International Standards Organization (ISO) requirements. [Ref. 34:p. 3]

2. 20 Foot ISO End-Opening Container

These containers are the standard 8 feet wide, 8 feet high, 20 feet long containers used in the commercial industry with one modification. The door-end cornerposts have been modified with an angle iron to allow wooden dunnage to be used without disturbing the force to the door. There is no permanent restraint system. These containers also have standard handling fittings on the top of the container as well as forklift pockets along the bottom.

The end-opening container will probably be the cornerstone of the DoD's general container system. It is

currently the standard throughout the commercial industry and is familiar to those who work with handling and stuffing/unstuffing containers. [Ref. 34:p. 7] (See Figure 3)

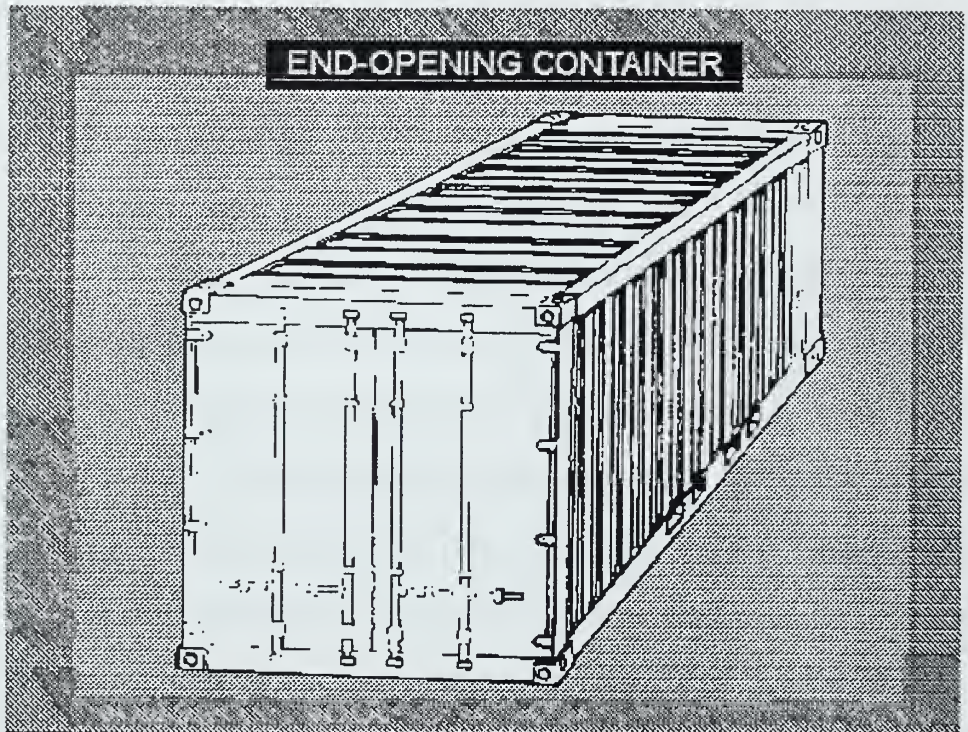
3. 20 Foot ISO Side-Opening Container

These containers are similar to the 20 foot ISO end-opening container with one difference: they have two double doors located on the side of the container instead of a door at one end. These containers provide easy access to their contents by forklift, and they also are fitted with internal tie down points for securing ammunition.

Side-opening containers provide a unique way to unstuff the container. It is easy for almost any forklift to reach the cargo inside, and consequently, this container type is used very successfully with many different sizes and types of ammunition. [Ref. 34:p. 13] (See Figure 4)

4. 20 Foot Half-Height Container

These containers are 8 feet wide and 20 feet long, but they are only 4 feet 3 inches in height. They have fixed sides and one end drops down to allow easy access by a forklift. Although there is no top on this container, bows and tarpaulins are provided to cover the contents. These containers are extremely useful for transporting very

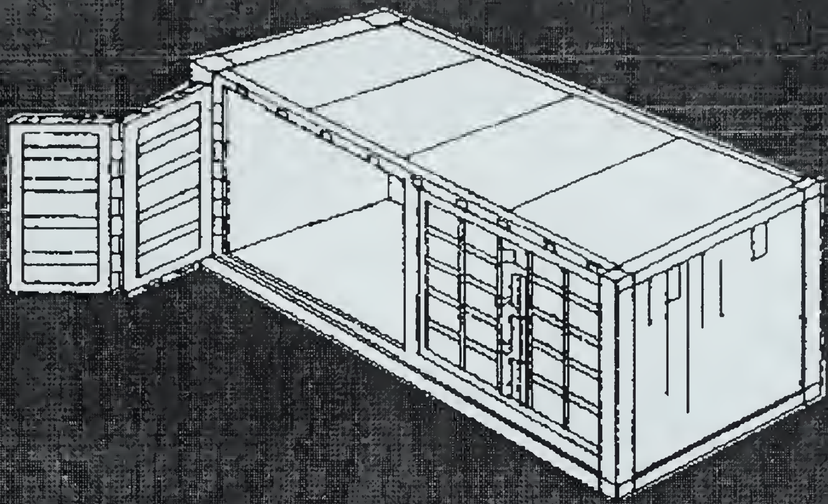


CONTAINER TYPE	
Ammunition Restraint MILVAN (8'x8'x20')	8115-01-363-8192
Ammunition Restraint MILVAN (8'x8.5'x20')	8115-01-363-8193
General Cargo MILVAN	8115-01-363-8194
20' ISO End Opening Container	8115-01-363-8195
20' Shipping / Storage Container	8115-01-363-4442

Dimensions (inches)		Military 20-foot	Commercial 20-foot	Commercial 40-foot
Internal	Length	231.0 - 231.5	228 - 233	431 - 475
	Width	91.1 - 92.0	80 - 94	89 - 94
	Height	88.2 - 93.3	83 - 95	77 - 107
External	Length	238.5	238.5	480
	Width	96	96	96
	Height	96 - 102	96 - 102	102 - 115
Door	Width	92	92 - 93	90 - 102
Opening	Height	83.5 - 89.5	83.5 - 89.5	89 - 102
Weight	Tare	5,000 - 13,240	3,000 - 5,565	6,000 - 10,000
(lbs)	Payload	31,560 - 39,800	39,245 - 41,000	56,400 - 61,200
	Gross	44,800	44,800	67,200

Figure 3. End-Opening Container [Ref. 2:p. II-8]

SIDE-OPENING CONTAINER



CONTAINER TYPE	NATIONAL STOCK NUMBER
USAF, 2 Fork Pockets	8145-L900411D
USAF, 4 Fork Pockets	8145-L900412D
Army	8115-01-363-8668
USAF, 4 Fork Pockets	8140-01-296-7241CU

Dimensions (inches)		Military 20-foot	Commercial 20-foot
Internal	Length	232.5	231 - 233
	Width	89.5	91 - 93
	Height	88	88 - 95
External	Length	238.5	238.5
	Width	96	96
	Height	102	96 - 102
Door Opening	Width	222	92 - 98
	Height	84.5	82 - 90
Weight (lbs)	Tare	5,000	4,200 - 4,360
	Payload	47,910	40,170 - 40,600
	Gross	52,910	44,800

Figure 4. Side-Opening Container [Ref. 19:p. II-12]

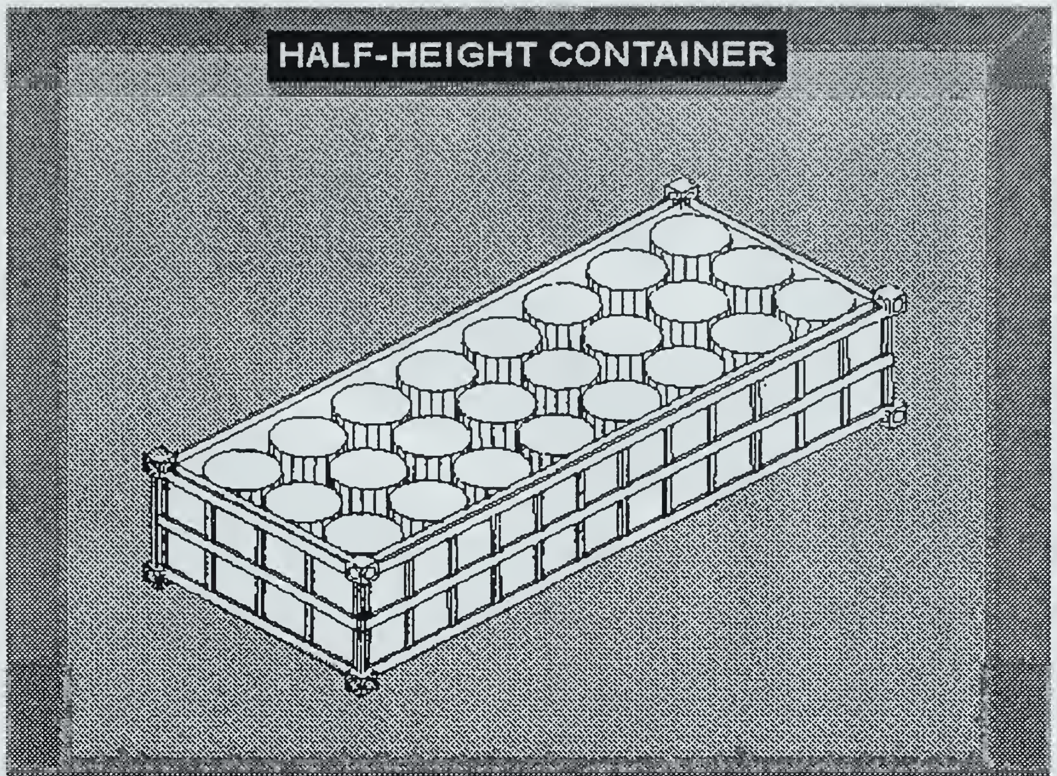
dense ammunition that does not require much space. [Ref. 34:p. 17] (See Figure 5)

5. 20 Foot Flatrack

A flatrack is a shipping platform with no top or sides, and may or may not have end-walls. Flatracks used for ammunition shipments are 8 feet wide and 20 feet long with end-walls, container handling fittings and forklift pockets. Flatracks are used to transport high cube munitions that are slightly larger than the door dimensions of a standard ISO container. The flatrack is the least desirable type of container to use with ammunition transportation because it does not provide much security for the ammunition; however, it may be used when quick jettison of the ammunition is required in the event of an emergency situation. [Ref. 34:p. 35] (See Figure 6)

6. Load and Roll Pallet (LRP)

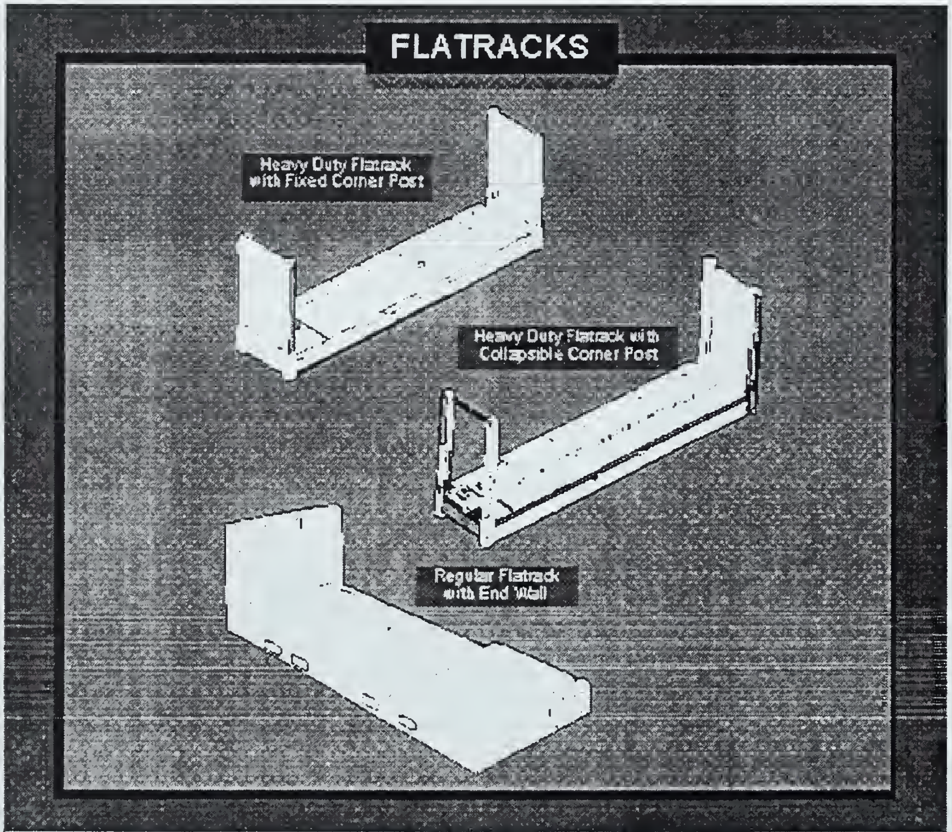
The LRP is a steel frame platform designed to fit inside a standard 20 foot ISO container. One end of the platform is fitted with rollers. To move the platform, the end without the roller is lifted by a forklift or a truck with a winch, and the load can be rolled into or out of a container. This system is exclusively used for the transportation of missiles such as a complete load of four Multiple Launch Rocket System (MLRS) pods or four Army



CONTAINER TYPE	NATIONAL STOCK NUMBER
Navy Half-Height (8'x4'x20')	8145-01-291-0937
Army Half Height (8'x4'x20')	Not Assigned

Dimensions (inches)		Military 20-foot	Commercial 20-foot
Internal	Length	229.75 - 233	232
	Width	90.625 - 92.4	92
	Height	37	37
External	Length	238.5	240
	Width	96	96
	Height	51	51
Weight (lbs)	Tare	5,000	4,189
	Payload	39,800	40,611
	Gross	44,800	44,800

Figure 5. Half-Height Container [Ref. 2:p. II-15]



CONTAINER TYPE	NATIONAL STOCK NUMBER
Navy	8145-01-290-7335
Army	Not Assigned
40' Heavy Duty	0910-LP-248-8600

Dimensions (inches)		Military 20-foot	Military 40-foot	Commercial 20-foot	Commercial 40-foot
Internal	Length	234	456	217 - 233	460 - 464
	Width	94	96	80 - 92	88 - 96
	Height	88 1	102 - 162	82 - 92	76 - 86
External	Length	240	480	239 - 240	480
	Width	96	96	96	96
	Height	96	132 - 186	102	102 - 108
Deck	Height	7.9	30	10 - 20	24 -26
Weight	Tare	6,500	22,000	4,900 - 6,516	10,042 - 11,903
(lbs)	Payload	38,300	144,000	38,540 - 59,990	55,840 - 89,170
	Gross	44,800	166,000	44,800 - 66,140	67,200 - 99,200

Figure 6. Flatracks [Ref. 19:p.II-20]

Tactical Missile System (ATACMS) pods. There are approximately 500 LRP units controlled by MTMC in the DoD inventory. [Ref. 34:p. 39] (See Figure 7)

7. Container Roll-On/Off Platform (CROP)

The CROP is a piece of handling equipment that is currently in the design and proving phase of development and is not yet in operational use. The CROP will handle general cargo as well as ammunition and is designed to fit inside a 20 foot ISO front opening container; it has front and rear locks that allow it to self-lock inside the container. The CROP will weigh about 3,300 to 3,700 lbs. Once installed, the CROP will allow easy access to the container contents via the rolling mechanism in its base. This will decrease stuffing and unstuffing times dramatically once implemented. The CROP is conceptually similar to the just described LRP, except that LRP is specialized for missiles while CROP is designed to accommodate a variety of commodities including most types of ammunition. [Ref. 19:p. III-3] (See Figure 8)

8. 50,000 Pound Rough Terrain Container Handler and Top Handler (RTCH & TH)

This equipment, with the top handler, can handle 20, 35, and 40 foot ISO containers with gross weights up to 50,000 lbs. over improved or unimproved terrain such as soft soil and beaches. A special fork kit is also available to lift 20 foot half-height containers, flatracks, loaded and

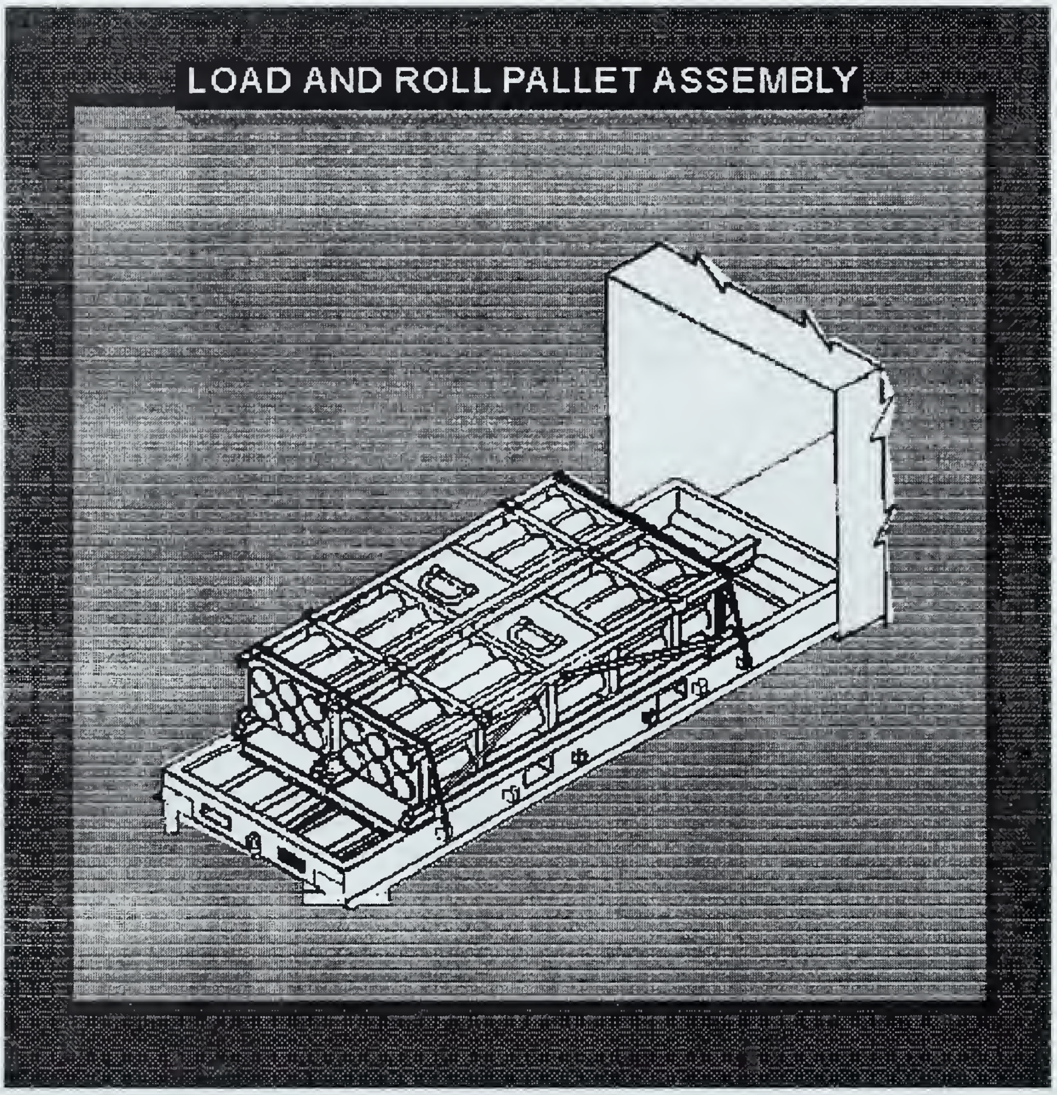


Figure 7. Load and Roll Pallet Assembly

[Ref. 19:p. II-21]

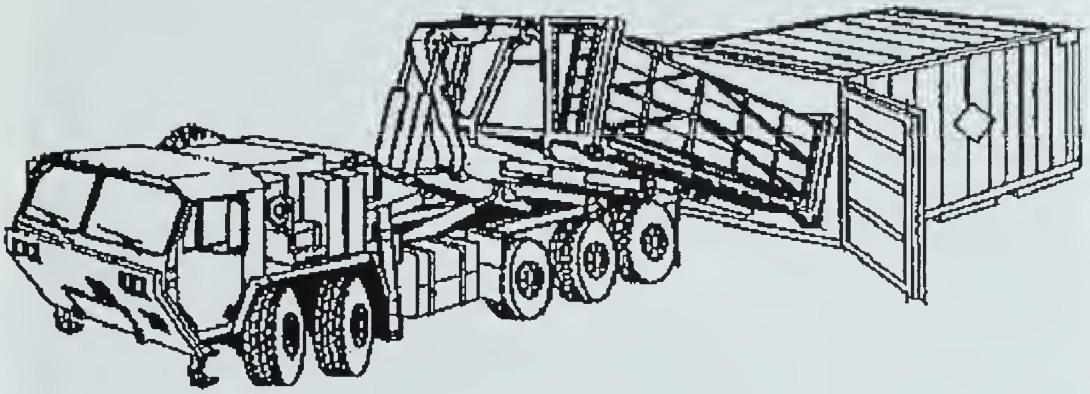


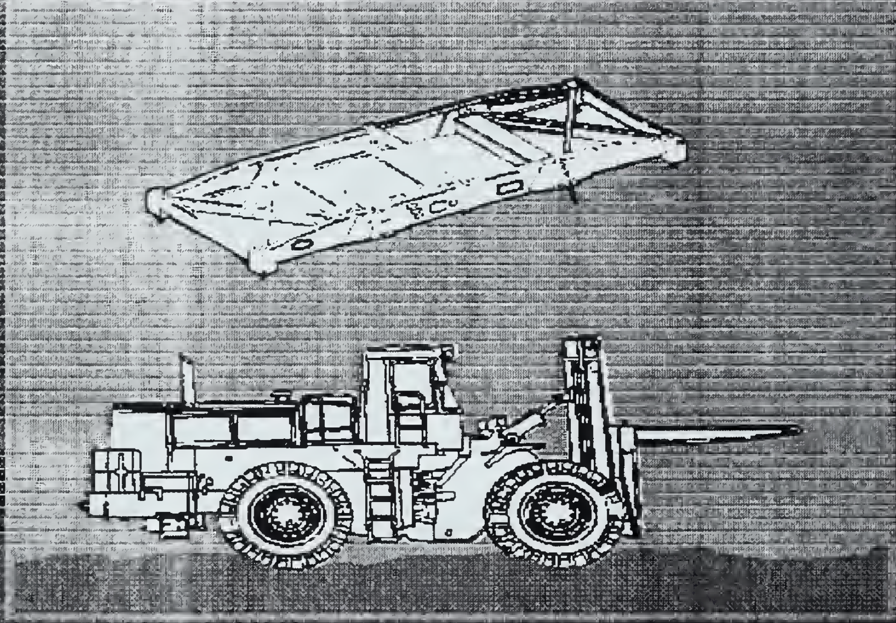
Figure 8. CROP with Palletized Loading System [Ref. 3]

empty CROPs, and containers with fork pockets as the only available lift fixture. The RTCH is a four wheel drive vehicle capable of driving through up to five feet of water. The RTCH provides extensive flexibility for container handling in the field. [Ref. 19:p. II-22] (See Figure 9)

9. Rough Terrain Container Crane (RTCC)

The RTCC is a wheel mounted crane capable of lifting a fully loaded ISO 20 foot or 40 foot container. This equipment can augment the use of a 50,000 Pound RTCH in the transfer of containers and other cargo between transportation modes and in storage areas. The RTCC can be operated on hard surfaces or on soft surfaces with wooden

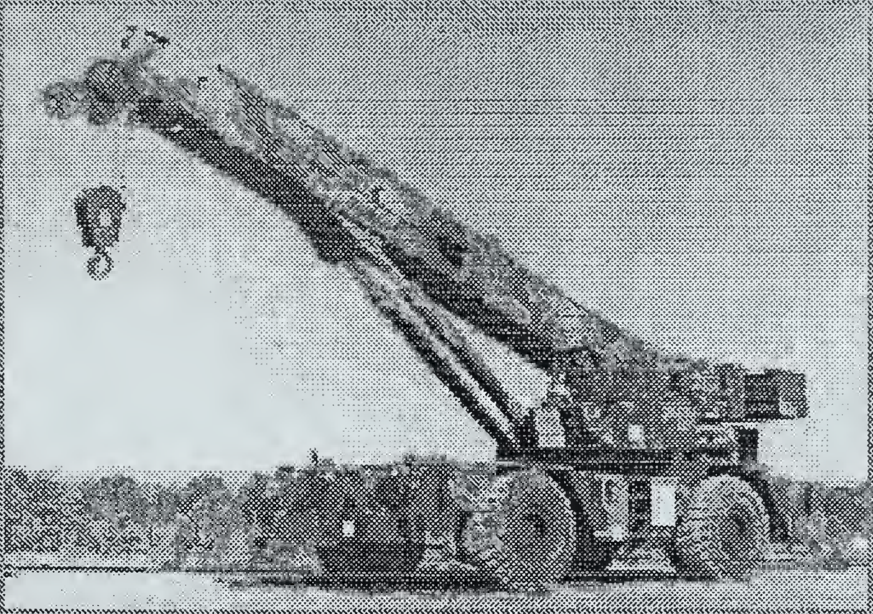
platform sections to support the weight. [Ref. 19:p. II-22] (See Figure 10)



National Stock Number Rough Terrain Container Handler (Army / Marine Corps)	3930-01-082-375[illegible]
National Stock Number Rough Terrain Container Handler (Air Force)	[illegible]
Capacity (lbs)	50,000 @ 48" load center
Length w/ Forks (inches)	420
Width (inches)	136
Height (inches)	167
Weight w/o Top Handler (lbs)	103,000
Top Handler Part No. (20- / 40-foot)	E9137 / E9140
Top Handler Weight (lbs) (20- / 40-foot)	3,800 / 9,927

Figure 9. Rough Terrain Container Handler and Top Handler [Ref. 19:p. II-25]

ROUGH TERRAIN CONTAINER CRANE



NATIONAL STOCK NUMBER	2810-01-205-2716
Capacity	44,800 pounds at 27- foot
Length (inches)	548
Width (inches)	145
Height (inches)	153
Weight (lbs)	108,750

Figure 10. Rough Terrain Container Crane [Ref. 2:p. II-23]

10. Palletized Load System (PLS)

The PLS is a tactical wheeled truck and trailer system with self load and unload capability utilizing removable flatracks. This vehicle is designed for field use and supports the Army's ammunition distribution system concept known as Maneuver Oriented Ammunition Delivery System (MOADS). This vehicle provides for the relocation of ammunition stocks to various ammunition supply points. [Ref. 19:p. III-2] (See Figure 11)

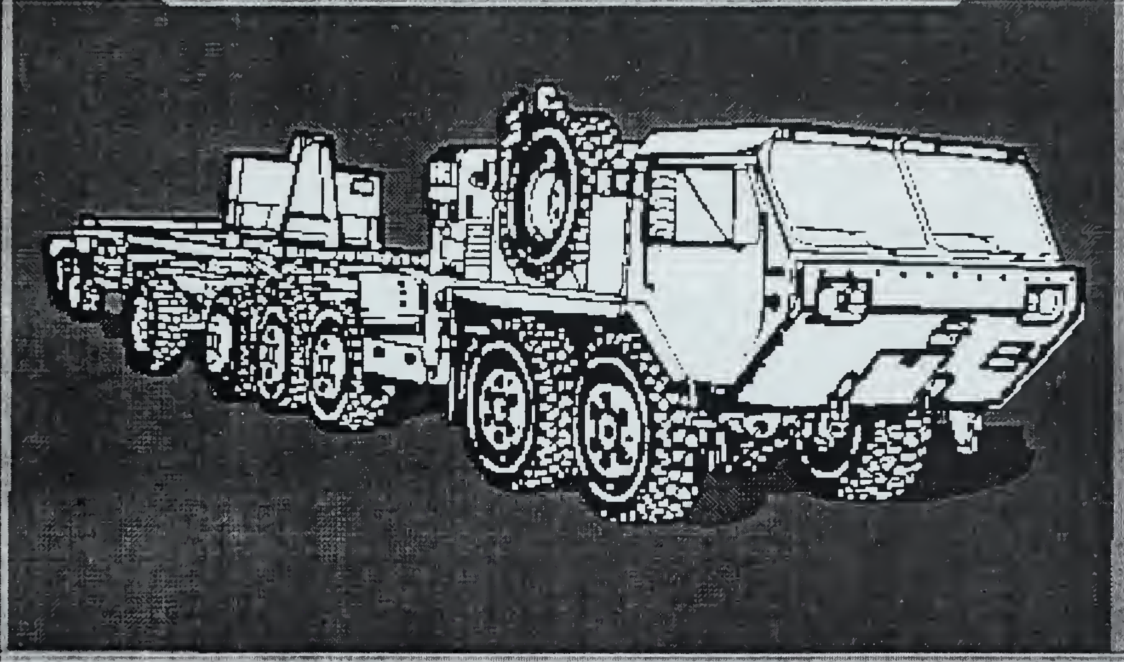
C. CONTAINER SHIPS

The transport of intermodal containers has led to the development of dedicated and combination (break-bulk and containers) container ship designs. There are four primary types of ships used in the intermodal transportation of ammunition:

- Non-Self-Sustaining Containership
- Self-Sustaining Containership
- Lighter Aboard Ship (LASH) vessels
- Barge Ships

Containerships, self-sustaining and non-self-sustaining, are specifically designed to carry all of their

BASIC PALLETIZED LOAD SYSTEM
TRUCK/TRAILER



TYPE EQUIPMENT	NATIONAL STOCK NUMBER
Truck with Materials Handling Equipment Crane (M1074)	2320-01-304-2277
Truck (M1075)	2320-01-304-2278
Trailer (M1076)	2330-01-303-5197
Flatrack (M1077)	3990-01-307-7676

Figure 11. Basic Palletized Load System Truck/Trailer

[Ref. 19:p. III-4]

cargo in ISO containers in cells below deck and stacked above deck. These ships can usually carry a mix of 20 and 40 foot containers. Containerships vary considerably in size from a capacity of 400 or less Twenty-Foot Equivalent Units (TEUs), to more than 6000 TEUs in the new super container ships. (See Figures 12 & 13)

LASH vessels are designed with holds and decks similar to containerships and have clear access to the stern for loading and unloading of individual barges. The LASH has a gantry crane that conveys the barges or lighterage between the vessel and the water. Containers and/or breakbulk cargo is stored on the individual barges then secured on the LASH for transit. This type of vessel has proven successful in TURBO CADS exercises and provides excellent flexibility with regards to port depths. The LASH's ability to debark the barges outside the port allow access to shallower areas. (See Figure 14)

Barge ships also provide flexibility for ocean transit of containers or breakbulk but are limited to the number of containers carried and are generally slower than the other vessels discussed here.

All but the Self-Sustaining Containership require crane services to load and unload containers from the ships or barges. Supplemental CHE is required if a port has minimal or no intermodal capabilities, such as cranes and forklifts.

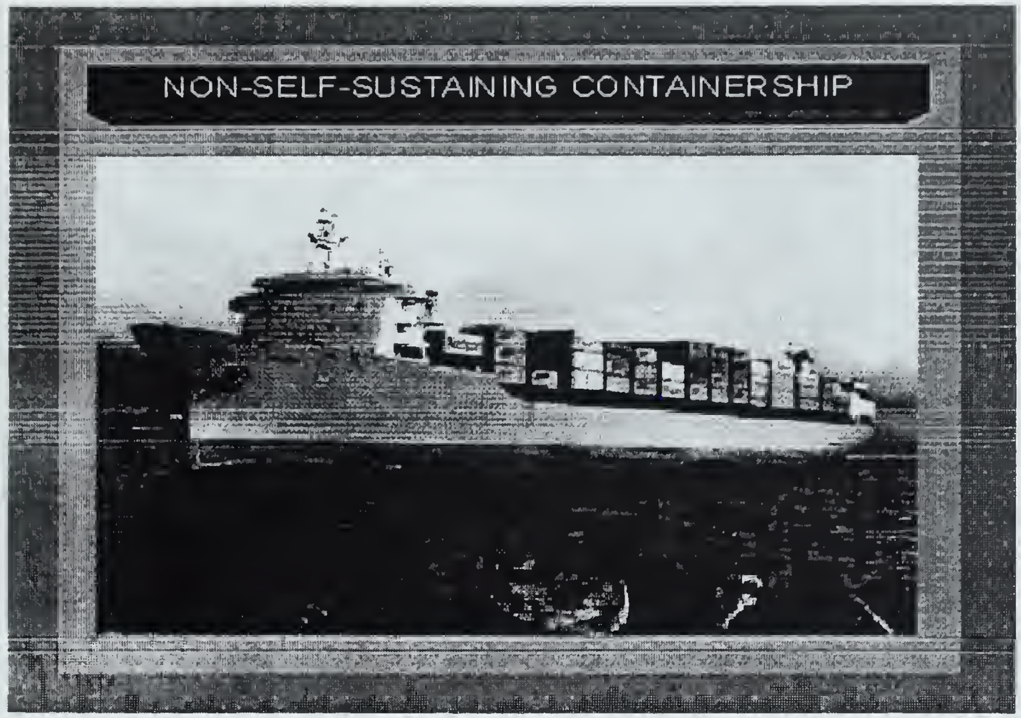


Figure 12. Non-Self-Sustaining Containership [Ref.19:p.III-6]

Figure 13. Self-Sustaining Containership [Ref.19:p. III-7]

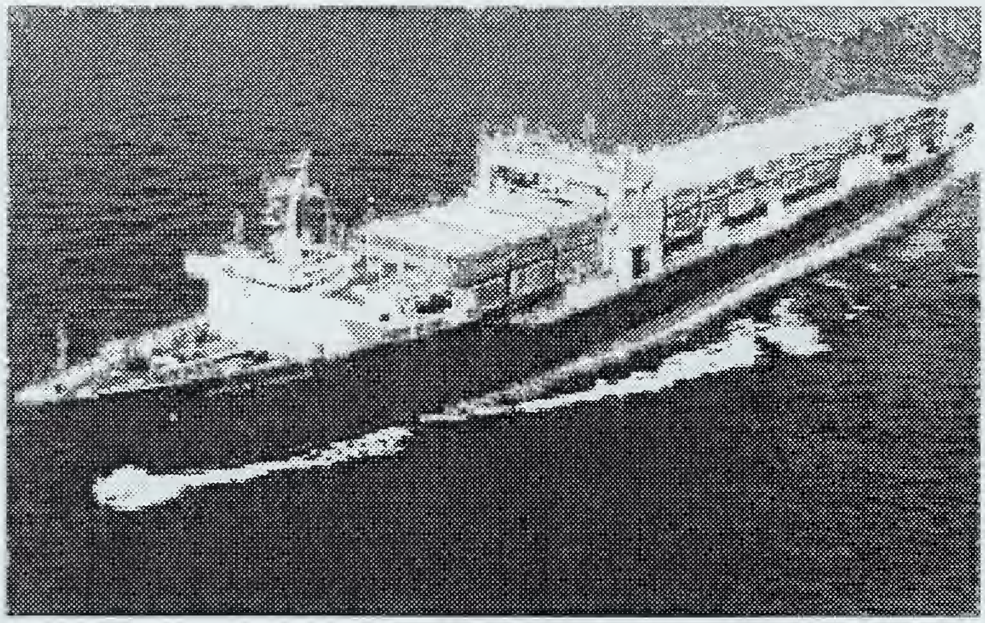


Figure 14. LASH Ship [Ref. 18:p. IV-4]

The DoD owns ten auxiliary crane ships (T-ACSs) which can be used to solely provide or augment the intermodal crane capability of a seaport of embarkation (SPOE) and/or seaport of debarkation (SPOD). The use of crane ships requires significant advance notice and planning to ensure the assets are available and in place. (See Figure 15)

The use of Roll On/Roll Off (RO/RO) vessels for the shipment of ammunition is limited. These vessels are specifically designed to carry wheeled and tracked vehicles as all or most of its cargo. Initial ammunition load-outs in tanks and trucks for artillery units are carried aboard in their respective vehicles but containerized ammunition for sustainment is not normally moved on RO/ROs.

Figure 15. Auxiliary Crane Ship (T-ACS) [Ref. 18:p. IV-8]

D. CONCLUSION

Intermodal transportation requires unique and special equipment. Transportation of ammunition intermodally requires even further specialization. The capital investments needed to put a system in place to fully transport ammunition intermodally is considerable; however, the efficiencies gained are greater. Labor, handling and storage costs are reduced while throughput is increased exponentially. With the commercial industry shifting to intermodalism, the infrastructure to support ammunition transfer is available and DoD directives are shifting the Defense Transportation System to an intermodal network. The future should allow for almost all ammunition to be transported intermodally from the depot to the foxhole.

In the next chapter, management systems, flow regulation measures, the flow process, and containerized transportation capabilities is discussed. The choke points and limitations in the supply chain are detailed, as well as the difference between wartime and peacetime flow.

IV. FLOW PROCESS OF THE AMMUNITION SUPPLY CHAIN

The ammunition supply chain is a flow process, which may be described in terms of the subject of the flow, the resources that enable the flow, and the communication that coordinates the flow. The subject of the flow is ammunition, which is stored at depots and can be transported either in containers or by breakbulk methods.

Where the previous chapter discussed the equipment that enables the flow, this chapter examines management systems at the wholesale and retail levels, and the regulation measures including communication systems, which coordinate the flow of ammunition. The capabilities and limits of the Defense Transportation System (DTS) are also addressed, including the implications of the Volunteer Intermodal Sealift Agreement (VISA) in the context of port capability.

A. MANAGEMENT SYSTEMS

The objective of an automated information system is to provide asset visibility including timely and accurate information on the location, movement, status, identity, and requisitions of ammunition. Having asset visibility will allow for greater military readiness. [Ref. 21, 24] This readiness will be attained by allowing the supply chain to

be responsive in identifying and moving priority munitions, the elimination of duplicate orders (a consequence of requisition visibility), and tracking the flow of munitions to identify possible choke points. Each service determines their own requirements for ammunition based on future year budgets, war plans, and distribution plans. [Ref. 31] Requirements for ammunition are sent to the Single Manager for Conventional Ammunition (SMCA) center who then determines how best to produce and where to store the ammunition at the wholesale level.

The center manages wholesale ammunition, coordinates the production base, and oversees the operations at five arsenals, ten depots, and twenty-two ammunition plants. [Ref. 13] The center consolidates requisitions from each service to gain efficiencies and economies of scale in the production of ammunition. The SMCA center performs the wholesale level management for each service and the retail management for the Army. The other services provide retail management through the use of Inventory Control Point (ICP) managers. Although the SMCA center performs wholesale management, each service operates wholesale information systems to maintain visibility and inventory data on their assets. [Ref. 31]

1. Wholesale Systems

At the wholesale level, the SMCA center maintains control through the use of several information systems, such as the Commodity Command Standard System (CCSS), the Standard Depot System (SDS) and Distribution Standard System (DSS), and the Worldwide Ammunition Reporting System (WARS) for the Army. The CCSS and other service's munition information systems interface through the Defense Automated Addressing System (DAAS) which acts as a information depository. [Ref. 20] The CCSS is a business system, which provides financial data and asset visibility of ammunition stored at Depots. The SDS is a legacy system and is currently being replaced by the Distribution Standard System (DSS). The DSS will provide Automated Information System (AIS) support for basic depot process operations such as receiving, storage, shipping, stock selection, packing, and transportation. [Ref. 20] WARS provides ammunition requirements and asset visibility for the Army and serves a link between the wholesale and retail level. [Ref. 26]

The Air Force maintains visibility and inventory data on wholesale assets through the Combat Ammunition System for Allocation (CAS-A), and the Marines use the Marine Automated Ammunition Report System II (MAARS-II). [Ref. 28,29] Besides interfacing with the SMCA center for visibility and

inventory data, these systems can pass requisition data to the SMCA, but not between the services. During wartime in a theater of operations, the Army is responsible for requisitioning all ground based ammunition for the Army and Marine Corps. [Ref. 31] It's not important to know how the systems of each service works, but what those systems provide to the managers. Unlike general supply information systems, which handle many commodities, ammunition is considered a specialized commodity and therefore has its own management system. Table 3 lists which ammunition information systems are associated with each service at the wholesale and retail level.

Level	SMCA	Air Force	Army	Marines
Wholesale	CCSS	CAS-A	CCSS	MAARS-II
Retail	WARS/SAAS	CAS-B/D	WARS/SAAS	ROLMS

Table 3. Ammunition Information Systems [Ref. 20]

2. Retail Systems

At the retail level, each service operates an information reporting system. Retail ICP managers mainly control ammunition that's used for training operations and the basic unit load of ammunition that an unit would deploy with during a contingency operation or actual deployment.

The Army uses the Standard Army Ammunition System (SAAS). The Air Force uses the Combat Ammunition System for Retail (CAS-B), and the Marine Corps uses the Retail Ordnance Logistics Management System (ROLMS). [Ref. 20] Each system is a management information system that integrates ammunition management and reporting functions from individual service retail sites to the theater storage sites and users in a combat zone. [Ref. 7, 31] The SAAS and CAS systems have sub-systems that are tailored to the requirements of the organizational level where they are located. For example, the Air Force uses the CAS-B in CONUS and, in a theater of operations, they use the CAS-D (Deployed). [Ref. 28] The Army uses SAAS-1/3 in CONUS and in the theater of operations. Each system provides similar data, but in different ways that are unique to each service. For an feel of what each service system accomplishes, the following is a list of functions that the SAAS system provides:

- Stock status summaries by location.
- Requirement computations and status of allocations.
- Visibility of stocks in-transit and transportation assets.
- Requisitioning data and maintenance information.
- Complete round status and information for higher level reports. [Ref. 7]

3. Future System

DoD is in the process of developing a new AIS called the Joint Ammunition Management System (JAMSS). The JAMSS will become the single Joint wholesale ICP and command level management system used by each service. It is scheduled for initial testing with the Marines in January 1999. [Ref. 32] The JAMSS will provide ammunition visibility and logistics functions throughout the wholesale and retail level. It will not replace each service's system, but serve as a bridge to link information for higher level management with connectivity through the Global Transportation Network. [Ref. 28,29,30,31,32] One of the major problems in Desert Shield/Desert Storm (DS/DS) was the lack of interface, data standardization, common machine language software, and hardware connectivity. [Ref. 22:p. 27] A goal of JAMSS is to provide total ammunition asset visibility, and a seamless flow of information to CINCs and service component commanders. The JAMSS will, in effect, standardize the management of ammunition in DoD through a common system and correct problems encountered during DS/DS.

The JAMSS is part of the Defense Total Asset Visibility Plan. [Ref. 20] One part of the JAMSS is the Munitions Transportation Management System (MTMS). The MTMS is a stand alone system operated by the Joint Movement

Transportation Coordinating Activity (JTMCA). The JTMCA is the:

> Focal point for export munitions ship planning, coordinating, and execution actions for those munitions moving aboard common user sealift...[It] consolidates all services munition requirements... into effective and efficient movement plans designed to provide... advance shipment planning visibility. [Ref. 17]

The SMCA center coordinates with the JMTCA who then provides transportation data to the depots and United States Transportation Command. The ability to provide usable information and visibility is the key to JAMSS. Visibility will give CINCs the capability to influence the ammunition flow depending on the fluidity of the situation.

B. FLOW REGULATION MEASURES

The flow of ammunition is constrained by the availability of the supply chain to transport and distribute the required ammunition to the right place at the right time. To govern the consumption of ammunition in a theater of operations, CINCs establish control measures to minimize the impact of ammunition in short supply or critical to mission success. The flow measures are known as the Required Supply Rate (RSR) or availability rate and the Controlled Supply Rate (CSR).

The RSR is the estimated amount of ammunition a combat commander will need to sustain operations without any

restrictions over a specified period of time. The estimate starts at the combat level and is expressed in rounds per weapon per day or as bulk allotment per day or per mission. As the threat of mission changes, so does the RSR. RSRs are consolidated at the theater level and compared against the total ammunition assets expected for the operation to create a CSR.

The CSR is the amount of ammunition that can be allocated based on the availability of ammunition assets, storage facilities, and transportation assets. The CSR is expressed in the same terms as the RSR. Combat commanders use the CSR to regulate the flow of ammunition to units engaged in operations. Depending on the level of intensity a unit may experience, the RSR may be higher for one location versus another. This is where the flexibility of the supply chain becomes a factor in supporting the warfighter. Flexibility includes the ability of transportation assets to move ammunition quickly, the ability to maintain visibility, and the ability to communicate with all units. Ammunition stockage levels are based on the projected supply rates and normally converted to short-tons to determine total daily tonnage lift requirements. [Ref. 7:p. 2-1-6]

These rates can be established during contingency planning based on factors, such as the expected type of

units supported, the amount of ammunition on-hand, expected time until resupply, and the level of anticipated operational intensity. The control rates direct the flow of ammunition into a theater and can be used to estimate how much ammunition should be shipped from CONUS. During Desert Storm/Desert Shield (DS/DS), ammunition requirements increased by 1500 percent as the mission changed from defensive to offensive, and General Schwarzkopf ordered a 60 day supply buildup in theater. [Ref. 22: p.138;23: p.161] This was based on expected combat operations, the enemy's potential to hamper sea transportation, and concerns with the transportation system. The assumption was that the extra supply would fix any potential resupply problems, but only instead caused choke points. [Ref. 23: p.161] If the enemy would have interfered with the flow of ammunition during DS/DS, combat units could have been limited to how much ammunition they could expend each day.

C. AMMUNITION FLOW PROCESS

For each service the handling and transportation of ammunition is almost the same until it reaches a theater of operations. Service ICP managers at the retail level receive requisitions from their units for ammunition. If service ICPs fill the requisition, then a source would be identified from retail or wholesale stocks. Each service would issue

from their retail stocks before requesting ammunition from the wholesale level. For ammunition controlled at the wholesale level, each service would send their requirements to the SMCA center. The SMCA processes the requisition and releases the ammunition for issue from a designated depot. The requisition is used by MTMS to derive transportation requirements for all ammunition that is exported. [Ref. 30] Using MTMS, JMTCA works with Military Traffic management Command (MTMC), Military Sealift Command (MSC), each service, and the depots to provide the most efficient way to transport munitions to the theater of operations.

During peacetime operations, the object is to minimize costs while meeting the Required Delivery Date (RDD) for each service or to support operations. Only two ships sail with ammunition to locations overseas each year, either to Europe or to the Pacific. In recent years, USTRANSCOM has used these ammunition shipments to evaluate the Containerized Ammunition Delivery System (CADS) in exercises called TURBO CADS. TURBO CADS addresses and studies the operation of transporting ammunition intermodally. During peacetime, ammunition is shipped through three military ammunition ports: Military Ocean Terminal Sunny Point (MOTSU), North Carolina; Concord Naval Weapons Station (NWS), California; and Port Hadlock, Washington. Military

Sealift Command (MSC) uses chartered ships, Ready Reserve Force (RRF) ships, and commercial ships to move ammunition from military ammunition ports.

During wartime, ammunition can move through commercial ports to the theater of operations. The majority of ammunition will be transported using sealift assets because of its characteristics. Only high priority, mission essential ammunition would be transported by air. During wartime, there are no limitations, such as minimizing cost, other than meeting the Required Delivery Date (RDD) set by the CINC. It is critical to have the right ammunition at the right place and time to support the warfighter during wartime.

When ammunition is received in a theater of operations, it is transported through designated locations such as ports (water and air), or by Logistics Over The Shore (LOTS) operations. LOTS involves the discharge of cargo from a anchored ship onto lighterage. It is then transported to a discharge site on shore. LOTS is used when developed ports are not available or to supplement the throughput capability of developed ports.

Ammunition is transported to storage areas such as the TSAs, CSAs, or ASPs for distribution to the user. Initially, ammunition is automatically pushed forward from

the TSA and CSA to units in the combat zone. This is referred to as a push system of resupply versus the pull system. A pull system ships ammunition after a requirement is generated, that is, in response to a user request or requisition. A push system moves ammunition based on planning factors. [Ref. 7]

D. TRANSPORTATION CAPABILITIES

Moving ammunition in containers involves an enormous infrastructure, which is provided by commercial and military resources. The infrastructure is part of the Defense Transportation System (DTS). The DTS incorporates sealift, airlift, surface transportation, and prepositioned equipment to transport ammunition, supplies, equipment, and personnel to the warfighter. The DTS supports the Joint Vision 2010 concept of focused logistics in "fusing information, transportation, and other technologies to allow precise delivery." [Ref. 11] Some key attributes of the ammunition supply chain are depot outload capabilities, port throughput, in-transit visibility, in-theater port and transportation capabilities. There are choke points, such as the lack of infrastructure or Container Handling Equipment (CHE), within each of these key attributes.

Intermodalism plays an integral part in the flow of ammunition by providing a fast, efficient, flexible, and high volume lift capability.

> Intermodalism is the concept of transporting… freight in such a way that all the parts of the transportation process, including information exchange, are efficiently connected and coordinated, offering flexibility. [It] is the seamless and continuous…transportation… on two or more transportation modes. [Ref. 25:p. 1]

For example, an ammunition container can be transferred from a railroad car directly to a ship. Using containers and intermodalism increases the utilization of the ammunition supply chain. Since containerization is the preferred method to ship munitions and only small percentages of munitions are airlifted, containerization and surface transportation will be the focus of this section.

A primary objective of containerization "is to obtain maximum efficiencies…at the lowest overall cost…[and] containers should be stuffed to the maximum extent possible" [Ref. 19:p. VI-12] Most containerization of ammunition starts at the depot when a container is stuffed with munitions (called outloading) and is then transported to a Port of Embarkation (POE). In the rest of this section, we discuss the capabilities of depots, ports, in-transit visibility, and in-theater operations.

1. Depot Capability

The ability of depots to outload containers is a function of the infrastructure, equipment, and labor available. The infrastructure includes road and rail networks, and container facilities. Equipment includes Material Handling Equipment (MHE), Container Handling Equipment (CHE), containers, and chassis. Labor includes the workforce needed to outload the containers. In recent years, all Tier I depots have undergone extensive construction to improve their ability to outload. Over $118 million in improvements was identified for rail and road networks, container holding areas, container repair facilities, and container pads (places to stuff containers) for Tier I facilities. Under current funding, these improvements for Tier I facilities are projected to be completed by fiscal year 2003. [Ref. 11]

MHE is used to stuff the container and CHE is used to make the intermodal transfer to a railcar, truck, or chassis. CHE and MHE are used extensively throughout the supply chain. Once ammunition is loaded inside a container, it moves as a unit load for the entire movement in the supply pipeline. The availability of proper container types is critical to outloading. Each depot maintains 4700 twenty-foot ISO containers for the initial shipment of

ammunition and relies on the commercial industry to supply additional containers. [Ref. 30]

TURBO CADS 1994 tested the concept of commercial industry providing containers for the shipment of ammunition. Because of the explosive nature and other characteristics of ammunition, an ammunition suitable container must be new or in nearly new condition. Industry's initial inability to provide suitable containers resulted in a recommendation that DoD communicate ammunition container requirements to the commercial industry more efficiently. The commercial industry has the ability to provide suitable containers, and in the future, greater emphasis will be placed on contracts for leasing containers. [Ref. 37]

Stuffing a container is usually labor intensive because individual pallets of munitions must be blocked and braced with wood dunnage inside the container. The use of new equipment such as Container Roll-On/Off Platform (CROP) may provide efficiencies in outloading. The CROP is a modified flatrack designed to fit inside a twenty-foot ammunition container. It is a reusable, relatively woodless dunnage system that consists of a flatrack and tie down points. The Palletize Loading System (PLS) can lift the CROP out of the

container without the use of CHE/MHE and transport it to the user. (CROP and PLS are both described in Chapter III)

The CROP eliminates the need for large amounts of wood dunnage which will save money and labor costs at the depot. Since each type of ammunition (configured as a single DODIC load or SCL/MCL) stuffed inside a container uses different amounts of dunnage, a cost comparison can only be estimated for each load. On average, $350 is spent on dunnage costs per container compared to $50 or less for the wood per each CROP use. The wood used with the CROP is for safety reasons to prevent sparking due to metal to metal contact. Additional savings should be realized through the reduction of labor needed to install dunnage. Additionally, the CROP can be accessed from three sides, possibly further reducing loading times. A load time of 10 minutes for the Load and Roll Pallet (LRP) for Multiple Launched Rocket System (MLRS) missile could be an indication some possible loading times. There is no data available comparing an individual container load time to a CROP loading time for specific types of ammunition or SCL/MCL. [Ref. 33]

The weight of the CROP flatrack (4,000 pounds) is a disadvantage. This weight prevents containers from being stuffed with as much ammunition as when traditional wood dunnage is used. Therefore, more containers may be required

to move the same amount of ammunition than without CROPs. [Ref. 30,33,35] Depending on other cost elements, using the CROP in peacetime may violate the objective of minimizing costs by stuffing the container to the maximum extent. Cost will be a minor factor during wartime. However, there is some possibility, requiring further research, that using CROPS for prepositioned ammunition could reduce the number of containers, facilitate rapid resupply of the services, and reduce the time for routine maintenance inspections. [Ref. 33]

Final production design specifications are currently being developed for the CROP. The are currently 12,780 CROPs on contract with options in place for an additional 12,780. [Ref. 3] The CROP is delayed from being tested in TURBO CADS 1998 due to production design changes. Before production, the CROP should be tested by the commercial transportation industry and seek approval from regulation agencies like the Coast Guard. [Ref. 33] Any efficiencies gained at the depot in outloading ammunitions will increase the throughput to the warfighter.

2. Port Throughput Capability

Once a container of ammunition leaves the depot, it is almost exclusively moved intermodally until it reaches the theater of operations. Within CONUS, containers will move

to a Port of Embarkation (POE) by rail or truck. The commercial industry, which is efficient in intermodal transportation, is normally used for these movements. During peacetime and wartime, the majority of ammunition, whether containerized or not, would move through one of the three military ammunition ports. Currently, MOTSU is the only containerized ammunition port with a capability of moving 600 Twenty-foot equivalents (TEUs) per day.

MOTSU is the designated East Coast ammunition port to support a Major Regional Contingency (MRC) West scenario. NWS Concord and Port Hadlock make up the West Coast ammunition port mainly to support a (MRC-East) scenario. Without a West Coast port, ammunition would take 31 days to move from MOTSU through the Panama Canal and to Korea versus 16 days from the West coast. There are ongoing improvements to NWS Concord and Port Hadlock that will increase there throughput capacity from a combined total of just over 250 to over 600 TEUs per day. [Ref. 2] The needed improvements listed in Table 4 were identified in the MRS and as a result of TURBO CADS exercises.

Commercial ports are restricted in how much ammunition can be throughput at one time. Ports are limited by the Quantity Distance (QD) requirements and Net Explosive Weight (NEW) of the ammunition per the Code of Federal Regulation

Concord	Port Hadlock
Gantry Cranes	Gantry Crane
Pier Upgrade	Rail Transfer Facility
Holding Pads	Truck Processing Center
Rail Repairs	Container Holding Lots
Channel Restriction Study	Transshipment Facility

Table 4. Needed Port Improvements [Ref. 2]

(CFR) 29 and 49. [Ref. 19:p. VI-14] The Coast Guard regulates waivers to exceed ammunition storage limits in ports during peacetime and wartime. Under the Voluntary Intermodal Sealift Agreement (VISA), commercial liners agreed that they will carry surge and sustainment cargo on regular liner service. Surge and sustainment cargo consists of unit equipment, general cargo, and ammunition. It is untested if commercial liner companies would risk shipping ammunition on regular container routes with commercial cargo. During the VISA Joint Planning Advisory Group (JPAG) meeting in April 1997, ammunition didn't meet the "criteria to be eligible for lift by a pure liner carrier." [Ref. 36:p. 4] Transportation of ammunition under VISA has not been fully tested in an exercise.

Several types of ships and barges provide sealift, such as Fast Sealift Ships (FSS), Lighter Aboard Ship (LASH), and container ships. When containers arrive at the Port of Debarkation (POD), the port may be either an industrialized fixed location such as Ad Damman, Saudi Arabia with 60

berths, or dependent on self-sustaining ships and (LOTS) operations. DoD has recognized the capability, effectiveness, and efficiency of using commercial intermodal transportation assets. The extensive use of containers makes CHE/MHE an essential element of the ammunition supply chain, but only large modern ports have the capability to move great amounts of containers at one time. [Ref. 18:p. II-9]

3. In-transit Visibility

As discussed previously, there are several information systems used by DoD to track ammunition. A system's ability to maintain visibility of ammunition is reliant on interfacing with commercial systems and receiving data from tracking devices. The use of Electronic Data Interchange (EDI) standards has enabled other systems to track ammunition by conveyance or container number while moving through a port and on a ship.

The emergence of Radio Frequency (RF) tags and bar codes has aided in the in-transit visibility of ammunition and general supplies. Both systems require readers to gather the data and transmit it to a user or information depository. In-transit visibility gives commanders the ability to influence the flow of ammunition depending on the situation. When the location of a container is known, it

can be redirected or prioritized for faster service. Potential problems include RF Tag reader and information system breakdowns. For instance, during TURBO CADS 95, the frequency of the tags for containers entering Japan interfered with the radio spectrum. [Ref. 38] This prevented testing of RF Tags during the exercise. The potential for overloading systems with data, or systems not communicating is also possible. This could lead to problems such as in DS/DS where an estimated forty-percent (about 25,000) of all containers were opened to determine the contents due to a lack of communication between and within the commercial industry and DoD. [Ref. 22:p. 182]

4. Lift and In-theater Capability

Lift at the POD is dependent on the discharge location and port facilities. This can vary from modern ports to ports that have no ability to off-load a ship. CHE/MHE resources can also pose problems with unloading a ship. During DS/DS, Ad Damman in Saudi Arabia was a modern facility, but shortages in CHE/MHE prevented the efficient reception, onward movement, and in-theater handling of containers. [Ref. 22:p. 182].

Depending on the situation at the port, commanders may need a self-sustaining ship with its own cranes to off-load containers. Another option is to off-load containers using

LOTS either because the port is damaged or to overcome port throughput constraints. Once the container is off-loaded, additional movement requires specialized CHE. Probably the most important type of specialized CHE equipment is the 50,000 pound Rough Terrain Container Handler (RTCH) because of its maneuverability and capabilities in various conditions.

Success in containerizing ammunition is dependent on the theater infrastructure and equipment necessary to handle containers. In DS/DS, the lack of infrastructure and CHE prompted the breakbulk transportation of ammunition instead of containerization. [Ref. 22:p. 185]

The limited availability of CHE and surface transportation can cause a choke point at the POD and at storage points. Containers can be transported by utilizing flatbed trailers, the PLS, and Host Nation Support (HNS) trucks. Some type of CHE will be needed to load/unload containers onto trucks and trailers, but a PLS can load and unload itself. The PLS can carry one container weighing up to 16.5 tons using a Container Lift Kit (CLK). The kit attaches to the end of a container and enables the PLS to lift and carry a container like a flatrack. The PLS, in effect, becomes the CHE and transportation. [Ref. 12:p. 15] The PLS is limited to lifting only one container.

If a container uses a CROP, the PLS can unload the CROP and move it forward to supply points in the theater. This could free up the ammunition container for retrograde movement or another use.

When a container arrives at its final destination, the ammunition must be unstuffed and stored. Manpower and time is required to unload a traditionally stuffed container. If ammunition is stored on a CROP, there are savings in manpower and time when unloading the ammunition. It takes an estimated four soldiers, one forklift, and sixty minutes to unload a fully stuffed container. With the CROP, it takes two soldiers, one PLS truck, and five minutes. [Ref. 35] CROPs with Strategic or Mission Configured Loads can increase the throughput and distribution of ammunition once it arrives in the theater.

E. CONCLUSIONS

The ability of the ammunition supply chain to meet the needs of the CINC are dependent on many factors throughout all three levels of war. The responsiveness of the chain relies on the coordination of each service and the ability of management systems to interface effectively. Efficiency is gained by minimizing the impacts of choke points in the flow. Some major choke points identified were the

outloading capability of depots, Container Handling Equipment (CHE), and in-theater operations.

The next chapter discusses recent operations and exercises involving the intermodal ammunition transportation system, including Desert Shield/Desert Storm and TURBO CADS exercises.

V. RECENT OPERATIONS AND EXERCISES

A. INTRODUCTION

The U.S. Military has utilized the intermodal system of transportation to different degrees in various operations. The uniqueness of ammunition presents a number of obstacles for intermodal transportation. United States Transportation Command (USTRANSCOM) has recognized these challenges and employed a series of exercises to address and study the operation of transporting ammunition intermodally. These exercises, called TURBO CADS (Containerized Ammunition Distribution System), have provided invaluable information and data for the analysis of ammunition containerization. This chapter looks at the development of containerized ammunition, and four of the TURBO CADS exercises from the years 1994, 1995, 1997 and 1998.

B. OPERATION DESERT SHIELD/DESERT STORM

Operation Desert Shield/Desert Storm was the first major U.S. Military conflict since the commercial container revolution. While containers were used in this effort, their full potential was not realized, and containers played a small part of the sealift operation. The initial thrust was partially supported by containers through the use of the

Maritime Preposition Ships (MPS). Of the 300,000 short tons of ammunition transported to the Gulf region during Desert Storm, only 5 percent was sent by container. The primary reasons for this containerization shortfall were:

- Limited availability of ammunition suitable containers.
- Lack of west coast containerized ammunition capability.
- Lack of container handling equipment at the units in the field and ports of debarkation. [Ref. 4:p. 49]

The United States also only had one containerized ammunitions port, Military Ocean Terminal Sunny Point (MOTSU), in Southport, North Carolina. All of the shipments from this specialized container port during Desert Shield/Desert Storm were by breakbulk. However, this inefficiency did not hinder the U.S. Forces due the large amount of staging time afforded by the scenario. Iraqi troops invaded Kuwait on August 2, 1990. President Bush ordered U.S. Troops to the area on August 7, 1990, beginning the portion of the operation known as Desert Shield. By November, the following force elements were in place: Four Army Divisions, one Marine Expeditionary Force (MEF), 1000 combat aircraft (approx.) and 60 Navy Ships. [Ref. 1:p.1]

The build-up continued until the first major air strike on January 17, 1991. The ground attack was launched on

February 24, 1991, and Kuwait was liberated on February 28, 1991. The deployment was very successful, but the fact that the United States had over three months to stage all troops, equipment, and supplies, including ammunition, did not make this a rapid deployment situation. The three months allowed ample time to get the ammunition in theater and staged. The Gulf War was also over very quickly, so the support system was not fully tested.

Desert Shield/Storm, however, did provide the U.S. Military with a view of the possibilities of containerized transportation and forced further study of its use.

C. MOBILITY REQUIREMENT STUDY

In the Fiscal Year 1991 National Defense Authorization Act, Congress tasked the DoD with conducting a study of the military's future mobility requirements. (This tasking was actually initiated in 1990, before Desert Shield.) The study was headed by the Director for Force Structure, Resources and Assessment (J-8) of the Joint Chiefs of Staff. In January 1992 they issued their expectations and recommendations as the Mobility Requirement Study (MRS). The primary focus of this study was strategic mobility, the ability to transport sufficient quantities of men and material in support of military contingency abroad. In the

area of containerization there were three main recommendations:

- Integration of containerization as the primary mode of ammunition transportation.

- Acquisition of a fleet of 20 foot containers and container handling equipment.

- Upgrade of existing facilities to appropriate output levels and establishment of a west coast container facility. [Ref. 14:p. VII-7]

These recommendations would make ammunition distribution more efficient, and would ensure that adequate amounts of ammunition would arrive in theater in time during a contingency. Establishment of the Concord, CA, Naval Weapons Station as an ammunition container facility would ensure adequate rapid container throughput to the Western Pacific and Indian Ocean areas.

The attention given to ammunition by the Mobility Requirement Study prompted USTRANSCOM to develop a series of exercises to test and develop the intermodal transportation of ammunition. These are the TURBO CADS exercises.

D. TURBO CADS 94

The first TURBO CADS operation was conducted in the Pacific Theater from August 1 to November 27, 1994, and was sponsored by USTRANSCOM. The operation was designed to test the effectiveness of intermodal ammunition transportation

by shipping munitions from multiple continental United States (CONUS) origins to multiple United States Pacific Command (USPACOM) destinations. The TURBOCADS 94 objectives were to:

- Evaluate on-hand container handling equipment and identify any container handling shortages.
- Identify shortfalls in the transportation system that could prevent the routine continuous use of containerized munitions.
- Demonstrate and evaluate the usefulness and convenience of blocking and bracing improvements compared to breakbulk.
- Observe and evaluate inland rail movements of containerized munitions to designated unstuffing locations in Korea.
- Observe and evaluate containerized munitions transfer operations at various inland locations.
- Assist in the development of container doctrine, as well as hardware requirements.
- Exercise NWS Concord's container throughput capability. [Ref. 37:p. 3]

The "lessons learned" from this exercise stated that the exercise effectively executed its objectives and proved to be fairly successful. One area did, however, cause significant concern. That was the lack of Container Handling Equipment (CHE). Borrowing and leasing CHE was the norm for areas with shortcomings. This presented a

potential hurdle in the smooth operation of containerized ammunition transfer.

The use of the two self-sustaining container ships for the exercise, *SS Gem State* and *MV Green Wave*, was appropriate because the Outside Continental United States (OCONUS) ports, at the time, did not have the capability to discharge a non-self-sustaining ship.

It was also noted that communication and dialogue between the commercial intermodal industry and the DoD required improvement. A recommendation was made that USTRANSCOM and commercial customers meet during the contracting process to clarify requirements and provide accurate information on capabilities of the planned depots and ports. Overall, 17,722 short tons were moved at a cost of $830/short ton for a total cost of $14.7 Million. [Ref. 38:p.10] With these points in hand, the stage was set for the next TURBO CADS exercise the following year.

E. TURBO CADS 95

The purpose of TURBO CADS 95 was to use the lessons learned from TURBO CADS 94 and improve on them. Many of the objectives were similar, but also included:

- Place more emphasis on partnership with the commercial transportation industry and civilian ports.
- Employ newer CHE technologies and doctrine.

- Provide and utilize a standing door-to-door contract with the carrier.

- Emphasize Army and Marine Corps operations more.

- Emphasize Korea, both in and out.

- Evaluate alternative dunnage.

- Evaluate Intransit Visibility (ITV). [Ref. 38:p.2]

Among the ports to be utilized and shipped to in TURBO CADS 95 were Valdez Alaska, Hawaii, Port Hadlock, NWS Concord, Okinawa, Misawa, Sasebo, Hiro, and Chinhae. The articles to be transported were:

- USAF - Standard operational munitions.

- Army - Training munitions.

- USMC - Training munitions.

This would use no more than 2000 containers in all. There was a combination of two plans under consideration in the initial exercise design phase. Together Plans A and B would provide for the total ammunition lift requirement.

The principal objective of Plan A was to utilize commercial door-to-door service, including the use of commercial ports. Two hundred and thirty-six TEUs were to be shipped from CONUS to Korea. There was particular interest in the capabilities of commercial West coast ports to ship containers to Pusan.

Plan B was to supplement Plan A by utilizing commercial door-to-door service, but routed through military instead of commercial ports. This would cover the remaining 1536 TEU lift requirement. Shipments were to go from NWS Concord to ports in Hawaii, Okinawa, Japan and Korea. These shipments were available to all US flagged carriers through open competition.

Plan A was not successful. Korea disapproved use of Pusan, so Plan A's container assignment was merged with Plan B. The movements were accomplished with MSC Charters and Commercial Carriers. A total of 30,780 short tons were moved for $596/short ton or a total of $18.3 Million.

There were several major lessons learned from this exercise. Commercial door-to-door service was not possible without conducting risk assessments and obtaining waivers for ports and intermodal transfer facilities. Limits and/or restrictions on Net Explosive Weight (NEW) must be worked out prior to port planning. Commercial waivers are very difficult to obtain but the Military Traffic Management Command (MTMC) has waiver authority for DoD facilities.

The west coast DoD munitions ports, Port Hadlock and NWS Concord, were not as effective as in the previous TURBO CADS exercise. Recommendations were made to continue full funding of the NWS Concord container port upgrade, to

upgrade Port Hadlock's container gantry crane, and to continue working munitions movements through commercial ports.

Commercial transportation industry response was fairly poor. Ocean carriers' proposals would not meet deadlines, and the lack of backloads from west coast ports caused slow truck support until increased funding was paid for deadhead mileage. Ocean, rail and truck carriers need to be included in exercise planning meetings to relieve these conflicts.

It was discovered that ITV through Automatic Identification Technologies (AIT) required host nation approval for radio frequency (RF) spectrum usage. This also needs to be incorporated into the planning phase.

Oceangoing tug-barges provided a viable strategic capability for sustainment and resupply. A 680 TEU tug-barge unit with a 120 ton crane and container handling equipment was self sustaining and reliable. They could make the trip from NWS Concord to Chinhae, Korea at 8-10 knots in 21-26 days, only 5-6 days longer than container ships. These vessels also provided an excellent platform for Joint Logistics Over the Shore (JLOTS) operations if port facilities were not available. [Ref. 38:p.16]

Overall, integrating CADS with existing commercial intermodal service proved to be very challenging. Hence,

this was to be the focus of the CENTCOM (Central Command) TURBO CADS 96 exercise. The 96 exercise was canceled however due to various reasons including difficulties in contracting services, obtaining port waivers and permits, and overall funding.

F. TURBO CADS 97

The objectives of the cancelled TURBO CADS 96 were planned to be revisited in 1997. United States Central Command (USCENTCOM) was again the area of interest for the exercise nicknamed "Depot to Desert 97".

TURBO CADS 97 was again sponsored by USTRANSCOM with an operational interest by the Chairman of the Joint Chiefs of Staff (CJCS). United States Commander in Chief Central (USCINCCENT) and United States Commander in Chief Pacific (USCINCPAC) were the supported CINCs for this exercise. The primary objectives were to:

- Meet supported CINC requirements.
- Exercise DoD/OCONUS munitions depots and ports.
- Exercise theater container management/distribution systems.
- Train personnel in container operations.
- Verify ability to handle munitions per the Operational Plan (OPLAN).
- Assess industry performance and responsiveness (leasing, motor, rail, ocean).

* Exercise commercial/Ready Reserve Force (RRF) sealift capability to move containerized munitions.

* Exercise DoD, industry, host nation interoperability (assets, facilities, procedures, and information systems). [Ref. 39:p.4]

This exercise had an initial requirement to call forward 777 TEUs to the area of operation. Planned Sea Ports of Debarkation (SPOD) were Kuwait and Ad Dammam, with 922 TEUs retrograde to return to NWS Concord. (145 of the retrograde TEUs bound for NWS Concord were not associated with the deployment portion of the exercise.) The sealift in this exercise was unique in that a Lighter Aboard Ship (LASH) vessel was utilized. The Ready Reserve Force LASH ship *Cape Farewell* was the chosen vessel. It has a sustained speed of 18.7 knots and could hold 150 TEUs stacked in forward holds, 252 TEUs in 36 barges in the mid-holds and 375 TEU on the weather deck. This exercise validated the use of LASH vessels modified for munitions containers. [Ref. 39:p.7-8]

The partial use of barges also provided increased flexibility in delivery of munitions containers. Barges from the LASH vessel were unloaded at the port entrance in Kuwait and moved by tugs to the off-load area. This reduced the required port draft by not requiring the LASH vessel itself to enter the port. Retrograde containers were also

returned to the LASH vessel in a similar manner. A plan is now being considered to modify four LASH vessels in the RRF to carry 1600 TEUs of containerized munitions per vessel.

The costs of Depot to Desert 97 included $5.5 Million for ocean transport, $3 Million for CHE and container leasing, $6.5 Million for port handling/inland transportation, and $227,000 for dunnage. The final after action report for TURBO CADS 97 is not yet available; however, LASH vessel concepts and port operation data appear to be beneficial.

G. TURBO CADS 98

This exercise, which has yet to be executed, will occur in the USCINCPAC Area of Responsibility (AOR) and focus on the following objectives:

- Meet and support CINC munitions requirements.
- Exercise the new container facility in Chinhae, Korea.
- Exercise the new intermodal container transfer facility at Naval Sub Base Bangor WA.
- Exercise DoD munitions ports NWS Concord and Port Hadlock.
- Exercise CONUS munitions depots.
- Exercise theater container management and distribution systems during Reception, Staging, and

Onward Movement (RSOI) exercise 98 or theater exercises.

- Exercise DoD as well as the foreign and domestic commercial industry (motor, rail, ocean).

- Train forces in container operations (container handling, stuffing, blocking, and bracing).

- Evaluate container leasing process (ordering, quality, and timeliness).

- Exercise new container hardware, if available (CROP (Containerized Roll On/Off Platform), PLS (Palletized Loading System), Improved RTCH (Rough Terrain Container Handler), and commercial CHE.

- Exercise joint munitions planning and execution procedures and systems.

- Exercise reserve transportation/ammunition handling units in OCONUS exercises, if available.

- Exercise strategic configured load concepts such as CAPEX (Combat Ammunition Production Exercise) and AMX (Air Mobility Express). [Ref. 40:p.2-4]

These objectives stress the actual operation of facilities, systems, personnel, and equipment more than the previous exercises. It is ambitious yet should provide invaluable data for current intermodal ability. The initial requirement requires 1000 TEUs called forward and 800 TEUs retrograde. While actual SPODs within the PACOM AOR are being determined, an emphasis of this exercise is on the CONUS SPOE (Sea Ports of Embarkation). Current funding for

the exercise is set at $12 Million funded by the JCS. Scheduled completion of the exercise is set for July 1998.

H. CONCLUSIONS

It is evident that the Department of Defense has recognized the container revolution and its place in transporting ammunition. Its own Mobility Requirement Study states that intermodal containers *should* be the primary mode of transporting ammunition. The development and implementation of a full scale system however is slow. Port regulations, commercial integration, and lack of required port infrastructure are a few of the primary problems being encountered in the shift to containerized ammunition. Through the use of TURBO CADS exercises, solutions to these problems are being explored.

The upgrading of NWS Concord is key to satisfying the container port requirements needed to achieve rapid global reach of containerized ammunition. Commercial ocean carriers must be incorporated into the planning for ammunition movement operations. The implementation of the VISA agreement must also be enforced to ensure sufficient vessels are available in the need of a crisis. VISA should also be implemented during occasional training operations to ensure the readiness of all units and ocean carriers involved.

Through the training of the TURBO CADS exercises, continued infrastructure development, and coordination with commercial entities, CADS can reach its full potential and rapidly provide U.S. Military forces with the ammunition required to sustain overwhelming superiority on battlefields around the world.

VI. ANALYSIS

The ammunition supply chain, like almost all systems, is in a perpetual state of change and development. This chapter analyzes key issues related to the success and/or failure of the system.

A. LIMITATIONS IN THE AMMUNITION SUPPLY FLOW

1. Depot Capabilities

The ammunition depot is the starting point in the ammunition supply chain. The physical act of stuffing containers with ammunition is time consuming and labor intensive. The use of wood dunnage to secure an ammunition shipment inside of containers is a meticulous process. The development of the CROP has the potential to reduce labor cost and stuffing time by streamlining the container loading and unloading process. Although still in development, the CROP has the potential to eliminate the use of dunnage and speed the loading and unloading process.

Additionally, depots can increase flow in the supply system by utilizing more configured loads (MCL/SCL) to ship outside of CONUS. Combining MCLs and SCLs with the CROP will minimize any potential re-configuration or re-stuffing of ammunition enroute to the end-users. This will require

increased planning to forecast planned ammunition usage, but will expedite shipment of ammunition containers by utilizing the unit load concept.

2. Port Throughput Capabilities

a) Ports of Embarkation (POE)

Once the containers of ammunition depart the depots, they enter the intermodal network of the commercial transportation industry. The efficiency and coordination of network intermodal operations should ensure timely delivery of containers to the Port of Embarkation (POE). The upgrades of the West Coast military ammunition port infrastructure at NWS Concord and Port Hadlock to achieve a 600 TEUs per day throughput are a positive step in relieving a very significant constraint. However, once the upgrades are completed, follow-up and recurrent testing of both ports' capability is necessary. The continued use of TURBO CADS exercises will test the improvements and offer suggestion for additional changes. The throughput capacity provided by these two ports is a major cornerstone for a Major Regional Contingency (MRC) East scenario and can supplement a MRC-West scenario.

b) Ports of Debarkation (POD)

Characteristics of the selected Ports of Debarkation (PODs) will greatly affect the possible throughput of ammunition to the user. Elements such as available roads, host nation support transportation, port offload capabilities, and available CHE are critical in avoiding potential choke points. Identifying and eliminating these potential choke points during contingency planning can reduce the impact of ammunition supply to the warfighter. One feasible method for smooth port entry is the use of tug-barges.

The introduction of oceangoing tug-barges can provide a viable strategic capability for transporting ammunition into a theater and reducing the impact of limited capability ports. The tug-barge, which was tested in TURBO CADS 96, provided an excellent platform to support LOTS operations and allow access to shallow ports. Unlike the LASH and Seabarge (SEABEE) Ships, which require additional CHE in port or up river, the tug-barge was self-sustaining because it carried a portable 120-ton crane. With the changing conditions of the world and the need to project forces anywhere, the introduction of versatile support concepts in the delivery of ammunition and other cargo is required. The

tug-barge concept should be used in contingency planning for austere port environments.

3. In-theater Lift Capabilities

Once ammunition containers arrive in-theater, forward movement is limited by the availability of transportation and CHE assets. Items such as the PLS, RTCH and RTCC (see Chapter III) are scarce resources that must be managed closely; a lack of these resources can limit the options of the warfighter. The use of a PLS with a Container Lift Kit will provide relief for limited CHE. In this role the PLS doubles it capability by allowing it to transfer as well as transport ammunition containers. When combined with the CROP, in-theater throughput can be greatly increased by not relying on limited CHE, and the time to unload a container is reduced. This combination adds flexibility to the ammunition supply chain on the battlefield.

B. FUTURE TRENDS

1. Management Systems

Military commanders require real-time information concerning material and logistics support capability in order to fight and win. The need for real-time information can be provided by the Joint ammunition Standard System (JAMSS) described in Chapter IV. The JAMSS has the potential for creating a seamless flow of information that will allow

commanders at all levels to maintain control, visibility, and status of ammunition assets. Incorporating the needs of each service in the design, development, and testing of the system can ensure that the system meets the needs all services and the warfighting CINCs. Maintaining visibility will give CINCs the capability to influence the ammunition flow depending on the fluidity of the situation. This will have a positive effect in reducing the fog of war by knowing and influencing the ammunition supply chain to provide the right product to the right place at the right time.

JAMSS has the capability to permit the coordination of DoD and commercial industry activities through one system. The cooperation and integration of each service along with commercial industry in the planning and development stages can facilitate an environment where jointness and each service's individuality is maintained.

Providing a seamless flow of information through visibility will increase the warfighter's readiness. Visibility provides a flexible and responsive ammunition supply chain and thereby acts as a force multiplier. Combining real-time information with the PLS and CROP, enables the warfighter to direct delivery of ammunition as needed to influence the outcome of a battle.

2. Container Roll On/Off Platform (CROP)

Part of the DoD Logistics Strategic Plan calls for the reduction in the cost and footprint of logistics support without reducing readiness. [Ref. 27:p. 4] The potential capability of the CROP and its associated cost could help DoD obtain this goal. Utilizing the CROP could result in cost reduction by:

- The reduction in dunnage needed to ship ammunition.
- The reduction in manpower required to load and unload a CROP.
- The reduction in CHE needed at the POD and in-theater through the use of the PLS and Container Lift Kit.
- Using the CROP with prepositioned stock to reduce the maintenance inspection time of ammunition.

Cost savings resulting from the decreased use of dunnage would be realized over time from multiple shipments of ammunition using the CROP. Potential cost savings in dunnage of $300 or more per container of ammunition will be realized. The projected cost of a CROP is $6,000 to $7000. Potential cost savings should result from using less dunnage per shipment, and less manpower to load and unload the container. Readiness is increased through the faster in-theater delivery of ammunition to the troops.

There is a weight trade-off of the CROP. The weight of the system, approximately 4,000 lbs., will obviously reduce

the usable weight capacity of the containers to hold ammunition, but the speed of loading and unloading will produce labor cost savings and increased throughput.

The CROP should be utilized with prepositioned ammunition containers to provide rapid delivery of ammunition to initial entry forces. Using CROPs in prepositioned containers can reduce the reliance on in-theater CHE, and provide mobility through ease of movement and transfer by the PLS anywhere on the battlefield. There are also potential savings during preposition ammunition maintenance cycles as the CROP would eliminate the need to remove and replace dunnage during inspections. Instead, the CROP would be rolled out, the ammunition inspected, then rolled back into the container.

There are other uses for the CROP besides moving ammunition. It can be used to rapidly move general supplies to combat units including water, food, and repair parts. The traditional PLS flatrack is currently being used in this way.

Further research and analysis of the CROP is needed to:

- Project accurate savings through stuffing containers with each type of munition versus using traditional methods of stuffing.

- Determine savings from the reduction in manpower requirements from less loading and unloading times.

- Determine the impact of utilizing CROP in prepositioned containers.

- Convert PLS flatracks to CROPs.

The CROP together with a container and the PLS can increase readiness through flexibility, ease of movement, and rapid accessibility.

3. Commercial Industry

The logistics foot print in a theater of operations may be reduced by continued and increased reliance on the commercial transportation industry to provide fast, accurate support.

Further development of the Voluntary Intermodal Sealift Agreement (VISA) with commercial ocean shippers should also be considered. Including ammunition as a qualifying criteria for lift by a pure liner carrier will be critical for utilizing all available means of transportation. The DoD needs to practice or exercise these agreements in peacetime as they would in war to fully analyze any shortcomings in the sea lift capabilities of commercial liners with respect to ammunition.

Under VISA, DoD would utilize the abilities of the commercial liner companies to move surge and primarily sustainment cargo to a theater of operations. The transportation of ammunition under VISA agreements needs to

be tested in peacetime and addressed during VISA JPAG meetings (see Chapter IV). The past VISA JPAG meeting in April 1997 did not address ammunition specifically enough to anticipate potential problems associated with transporting ammunition through commercial ports or on commercial liners with commercial cargo. [Ref. 36] VISA participants should, to a feasible extent, be periodically exercised in ammunition transport to test and increase readiness.

Shipping ammunition with valuable commercial cargo is a significant risk in the case of an emergency aboard the carrier or in port. During war, this risk may be out weighed by the benefits to National Security in providing timely support to the CINC. Even so, the benefits of peacetime training are less likely to out weigh this danger to private citizens and property. These benefits and risks merit further analysis.

4. New Equipment

New equipment developments in the commercial transportation industry need to be examined to determine their impacts (positive or negative) on the ammunition supply chain. The commercial industry has made improvements in the transportation of intermodal containers through the development of new equipment such as deep-well double stack railroad container cars. These cars are designed to hold

two forty-foot containers or up to four twenty-foot containers, depending on the total weight of the containers. However, the deep-well railcar may need a different type of container handler or overhead crane to load containers other than what depots now have in inventory. The ability of depot CHE to load a deep-well railcar is unknown. Without the ability to load this type of railcar, depots would have to make sure they request other types of container railcars. The first test of a depot capability to load a deep-well railcar is scheduled to take place within the next three months. [Ref. 33]

Another development is the shift to using forty-foot containers for overseas movements by transportation companies. DoD's current dependency on the supply of twenty-foot containers may be in jeopardy in the future. This could present a problem in the intermodal movement of containers at depots and in-theater. Current ongoing improvements in the ammunition supply chain, such as depot upgrades and port upgrades, are for transporting twenty-foot containers. It is unlikely that any near-term impacts will result. However, this development emphasizes the need to keep abreast of commercial developments, and the potential impact to the DTS, including the ammunition supply chain.

This shift to forty-foot containers for international shipments may also benefit the ammunition supply chain. There is the possibility of loading two CROPs in a forty-foot container, but this needs further research to address:

- DTS problems and in-theater capabilities.
- What type of CHE/MHE would be needed to unload the second CROP given that a PLS can pull out the first one.
- Possibility of ammunition weight exceeding CHE and container capability, or railcar weight limits.
- Possible development of forty-foot containers with doors on each end.

5. Organizational Cooperation

An advisory board needs to be established to examine new developments in the commercial world that affect the ammunition supply chain. This board should include organizations such as USTRANSCOM, IOC, Joint Ordnance Command Group, Joint Transportation Board, Maritime Administration (MARAD), Coast Guard, ammunition regulatory agencies, and commercial industry representatives. The duties of present boards could be expanded to address this need.

DoD needs to facilitate close coordination with regulatory agencies in the development of equipment used to transport and handle ammunition. Including these agencies in

the different phases of development will aid in the acceptance of the equipment and policies enforcing safety standards. This coordination can alleviate confusion and choke points by examining how new developments like the CROP will impact agency policies and regulations, and provide solutions before the product is developed.

The suggestions presented in this chapter should provide insight with respect to problems and trends that will develop in the future. Understanding these problems will enable managers, planners, and users of the ammunition supply chain to anticipate the dynamic environment of shipping ammunition through the intermodal transportation network.

VII. CONCLUSIONS AND RECOMMENDATIONS

The final chapter of this thesis provides conclusions and recommendations based on the authors' research and analysis of the ammunition supply chain. Additionally, proposed further research questions are introduced to provide subject matter for future development and analysis of the containerized ammunition transportation process.

A. CONCLUSIONS

Incorporating the development of new equipment and concepts to make the ammunition supply chain more flexible and responsive is a step in the right direction toward supporting CINC's. The ability of the Defense Transportation System to transport ammunition is adequate, but there are areas that require improvements to increase the utility of the ammunition supply chain. These areas include the upgrades of West coast ports, intermodal equipment developments, and organizational coordination between DoD, regulatory agencies and commercial industry.

1. Port Upgrades

The infrastructure upgrades of NWS Concord and Port Hadlock to achieve a throughput of 600 TEUs per day are positive steps toward increasing the throughput of containerized ammunition. Currently, these ports are choke

points in the flow of containerized ammunition from the West coast.

2. Intermodal Equipment

The pool of intermodal equipment available in CONUS is not currently a problem, but once ammunition containers arrive in-theater, forward movement is limited by the availability of transportation and CHE assets. Items such as the Palletized Load System (PLS) and Rough Terrain Container Handler (RTCH) are scarce resources that must be managed closely because their capabilities act as a force multiplier. The lack of these resources at critical areas in the ammunition supply chain limits the flow of ammunition to the troops.

The commercial industry has made improvements in the transportation of intermodal containers including the development of new equipment, which makes the ammunition supply chain more responsive. The development of new equipment, such as deep-well double stack railroad container cars, has shown the potential to make the transportation of containers more efficient, but the impact of this development on the ammunition supply chain is uncertain.

3. Organizational Coordination

DoD maintains several management and information systems to coordinate the full spectrum of transporting

ammunition to the battlefield. Multiple systems operated independently by each service exacerbate the difficulties of coordinating the ammunition supply chain.

Individual services can no longer afford to act without communicating with each other. The development of an integrated management system will ensure that the individual services will function as one in a joint environment.

DoD coordinates with other agencies on new equipment development in the transportation of ammunition, but this coordination isn't fully integrated early in the equipment development process. Because of the inherent dangers involved in the transportation of ammunition, coordination is required to gain safety approval and identify potential setbacks involving the development of equipment used to transport and handle ammunition.

B. RECOMMENDATIONS

1. Further Development of CROP System is Warranted

The Container Roll On/Off Platform (CROP) has the potential to reduce costs and the footprint of logistical support associated with containerized ammunition operations. Through continued development and implementation of the CROP system, reduction in required dunnage, labor, maintenance and associated CHE can be realized as well as increased flexibility, ease of movement and accessibility. This

system will be the cornerstone of an efficient intermodal system for both ammunition and conventional cargo for supporting the warfighter.

Utilization of the CROP must be a key element in future TURBO CADS exercises in order to demonstrate, train and prove the effectiveness of this system. DoD's current effort in CROP development is promising and should be fostered, including input from all armed services, until full implementation of the CROP system has come to fruition.

2. Continue Development and Implementation of JAMSS

The need for a real-time information management system for logistics support is critical in the new information warfare age and joint operational environment. The Joint Ammunition Management Standard System (JAMSS) has the capabilities to provide full asset visibility through timely and accurate data pertaining to containerized ammunition. DoD should continue to develop and implement the JAMSS. This will allow commanders of all services to control their ammunition supply line, including interfaces with commercial industry.

3. VISA Exercises and other Commercial Coordination

VISA should be exercised more often in peace time operations to ensure commercial industries' readiness for an actual contingency. A recurring issue of the TURBO CADS

exercises is the lack of commercial industry cooperation. This is partly based on the DoD's failure to fully include the ocean carriers in the planning phases of these exercises. This is easily remedied and should be considered in future exercises besides TURBO CADS such as Bright Star and Cobra Gold.

4. Follow-up and test New Infrastructure at Military West Coast Ammunition Ports

The intermodal port upgrades at NWS Concord and Port Hadlock must be completed and fully tested. Through future TURBO CADS exercises, the goal of a sustained 600 TEU daily throughput can be evaluated. These ports represent the gateway to the Pacific for outbound ammunition containers and supplement other areas around the world. If the 600 TEU throughput is not realized, then action to bring the deficient port(s) up to specification must be implemented.

5. Coordination with Regulatory Bodies

Increased coordination is needed with regulatory agencies by the DoD in the development of equipment used to transport and handle ammunition. This coordination will aid in the acceptance of new equipment and in development of policies affecting the transportation of ammunition.

6. Monitor Changes in Intermodal Technology and Operations

An advisory board needs to be established to examine new developments in the commercial world that affect the ammunition supply chain. This board should include organizations such as USTRANSCOM, IOC, Joint Ordnance Command Group, Joint Transportation Board, Maritime Administration (MARAD), Coast Guard, ammunition regulatory agencies, and commercial industry representatives.

C. FURTHER RESEARCH QUESTIONS

1. CROP Cost Analysis

With implementation of the CROP system in the near future, further understanding of its benefits and a detailed cost analysis of the system would provide valuable data for implementation, design improvements, and cost benefits to the DoD. The analysis should examine manpower, the logistical footprint, and load size issues, as well as possible alternatives for transporting cargo other than ammunition. Additionally, further research should be conducted to explore using CROPS for prepositioned ammunition which could reduce the number of containers, facilitate rapid resupply of the services, and reduce the maintenance inspection time for routine inspections. As the

prototype CROPs enter field use, more data will be available for this analysis and study.

2. Implications of Future use of 40 ft. Containers

With the gradual shift of commercial industry to the use of 40 ft. versus 20 ft. containers, CHE/MHE compatibility issues within the DTS will definitely arise. This includes port capabilities and the available container fleet. Future research into this trend is warranted.

3. Implications of the Double-Stack Well Railcar

Double-stack well cars are providing an ever increasing proportion of the container throughput capacity of the domestic railroad industry. Compatibility issues should be researched to determine the ability of depot CHE to operate with this type of railcar. Additionally, weight limitations issues involving ammunition containers and the rail car should be explored.

4. Risks and Benefits of Loading Ammunition with Commercial Cargo during Peace and War

Currently, ammunition is not considered a qualifying criteria for pure lift by a liner carrier. This issue will prohibit ammunition from being carried on commercial liners with other commercial non-explosive cargo. It requires a liner to be completely loaded with ammunition, or a liner dedicated to carrying ammunition solely for a partial load. A possible shortfall in the total lift capabilities for the

sustainment of ammunition could result. This issue requires significant attention and resolution though VISA.

Shipping ammunition with commercial cargo is a significant risk. During war, this risk may be out weighed by the benefits to National Security. However, the benefits of peacetime training are less likely to out weigh the danger. These benefits and risks merit further analysis.

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LIST OF ACRONYMS

ACS	Auxiliary Crane Ships
AIT	Automatic Identification Technologies
AMC	Army Material Command
AMX	Air Mobility Express
AOR	Area of Responsibility
ASP	Ammunition Supply Point
ATACMS	Army Tactical Missile System
ATP	Ammunition Transfer Point
CADS	Containerized Ammunition Distribution System
CAPEX	Combat Ammunition Production Exercise
CAS	Combat Ammunition System
CCL	Combat Configured Load
CCSS	Commodity Command Standard System
CENTCOM	Central Command
CHE	Container Handling Equipment
CINC	Commander In Chief
CLK	Container Lift Kit
CMMC	Corps Material Management Center
CONUS	Continental United States
CROP	Container Roll On/Off Platform
CSA	Corps Supply Area
CSR	Controlled Supply Rate
DAAS	Defense Automated Addressing System
DAO	Division Ammunition Officer
DMMC	Division Material Management Center
DoD	Department of Defense
DODIC	Department of Defense Identification Code
DS	Direct Support
DS/DS	Desert Shield/Desert Storm
DSS	Distribution Standard System
DTS	Defense Transportation System
FSS	Fast Sealift Ship
FSSG	Forward Service Support Group
GS	General Support
HNS	Host Nation Support
ICP	Inventory Control Point
IOC	Industrial Operations Command
ISO	International Standards Organization
ITV	Intransit Visibility

JAMSS	Joint Ammunition Standard System
JLOTS	Joint Logistics Over the Shore
JTMCA	Joint Munitions Transportation Coordinating Activity
LASH	Lighter Aboard Ship
LRP	Load and Roll Pallet
MAARS	Marine Automated Ammunition Report System
MCC	Material Control Center
MCL	Mission Configured Load
MEU	Marine Expeditionary Unit
MHE	Material Handling Equipment
MLRS	Multiple Launch Rocket System
MMC	Material Management Center
MOADS	Maneuver Oriented Ammunition Delivery System
MOTSU	Military Ocean Terminal Sunny Point
MPS	Maritime Preposition Ships
MRC	Major Regional Contingency
MRS	Mobility Requirement Study
MSC	Military Sealift Command
MTMC	Military Traffic Management Command
MTMS	Munitions Transportation Management System
NEW	Net Explosive Weight
NICP	National Inventory Control Point
NWS	Naval Weapons Station
OCONUS	Outside Continental United States
OPLAN	Operational Plan
PLS	Palletized Loading System
POD	Port of Debarkation
POE	Port of Embarkation
RDD	Required Delivery Date
RF	Radio Frequency
ROLMS	Retail Ordnance Logistics Management System
RO/RO	Roll On/Roll Off Vessel
RRF	Ready Reserve Force
RSOI	Reception, Staging, and Onward Movement
RSR	Required Supply Rate
RTCC	Rough Terrain Container Crane
RTCH TH	Rough Terrain Container Handler and Top Handler
SAAS	Standard Army Ammunition System
SCL	Strategic Configured Load

SDS	Standard Depot System
SEABEE	Sea Barge
SMCA	Single Manager for Conventional Ammunition
SPOD	Sea Ports of Debarkation
SPOE	Sea Ports of Embarkation
TAMMC	Theater Army/Area Material Management Center
TEU	Twenty-foot Equivalent Unit
TSA	Theater Storage Area
TURBO CADS	Containerized Ammunition Distribution System Exercises; TURBO denotes USTRANSCOM sponsorship
USCENTCOM	United States Central Command
USCINCCENT	United States Commander in Chief Central
USCINCPAC	United States Commander in Chief Pacific
USMC	United States Marine Corps
USPACOM	United States Pacific Command
USTRANSCOM	United States Transportation Command
VISA	Volunteer Intermodal Sealift Agreement
WARS	Worldwide Ammunition Reporting System

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